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A RAILROAD UNIVERSITY. ALTOONA AND ITS METHODS.

By Frederic Blount Warren, in the Engineering Magazine.

More than 10,000 men are in daily attendance upon the largest railroad university in the United States, which is conducted by the Pennsylvania Railroad at Altoona, Pennsylvania. Altoona is a busy little city of 50,000 persons and for the month of December, 1906, 13,000 men received at that point pay checks aggregating $825,000 from the one corporation which practically controls the destinies of the municipal population.

First of all, Altoona is a railroad city, where the industries, clubs, churches and society exist in a railroad atmosphere. It is the home of the largest freight yard in the world, this being 7 miles long from end to end and accommodating a total of 221 miles of track. In one month last year 154,412 cars passed through the town. Dozens of trains, laden with coal, come from the mountain districts every day; the cars are separated and classified and the new-made trains roll eastward. The total movement of freight cars through the Altoona yards in one year was 2,004,603; the average a day is about 6,000 cars. Ninety-nine freight trains have been known to come in from the West in a single day of twenty-four hours.

Four important branches of railroad work are quartered and conducted here, affording the student of railroading a more thorough technical training than he could obtain at any other point in the United States. They are: the machine shops, I. B. Thomas, master mechanic, where locomotives are repaired; the car shops, W. F. Eberle, general foreman, where new cars are built and old ones repaired; the Juniata shops, W. H. Bennett, master mechanic, where only locomotives are built and none are repaired, and the South Altoona foundries, E. McLean, general foreman, where car wheels to the number of 900 daily are made, as are also general castings for locomotives, cars, and miscellaneous work.

The Juniata plant is the only locomotive shop in the United States owned by a railroad and exclusively devoted to the building of locomotives. The Altoona machine shops are the best known in the country. At the present time they are repairing about 200 locomotives a month. The shops were commenced in 1850, four years after the road was completed over the Allegheny Mountains. Each of the three erecting shops has three longitudinal tracks, two of them have three overhead traveling cranes each, and the third shop has two supplemented by three electrical wall cranes on each side of the shop.

Already one of the best equipped plants in the United States, the Juniata shop increases in size or is improved in some way almost every year, but

(Continued on page 26324.)

THE JUNIATA SHOPS, LOOKING FROM THE HILL.

THE JUNIATA BOILER SHOPS, SHOWING RIVETING MACHINES.

ELECTRIC PLANT, HYDRAULIC AND ELECTRIC BUILDING.

HYDRAULIC PUMPS IN THE JUNIATA SHOPS.

[Continued from SUPPLEMENT No. 1642, page 26311.]

ARTIFICIAL FERTILIZERS: THEIR NATURE AND FUNCTION.—IV.*

By A. D. HALL, M.A., Director of the Rothamsted Experimental Station, Lawes Agricultural Trust.

ALTHOUGH, under ordinary farming conditions, an actually acid reaction is not likely to arise through the use of sulphate of ammonia, the experiments at Woburn and Rothamsted clearly indicate that it is not a desirable source of nitrogen for soils which are deficient in calcium carbonate. The reaction of ammonium salts with the soil, resulting in the withdrawing of the ammonia from solution, gives a clue to the difference in both the yield and the character of the crop when grown with sulphate of ammonia and nitrate of soda respectively. On the grass plots at Rothamsted, for example, where the manuring has now been repeated year after year for fifty years, very distinct types of herbage have associated themselves with the two manures. Putting aside the prevalence of sorrel as due to the acid conditions also brought about by the ammonia salts, the characteristic grasses are of shallow-rooted habits, e. g., sheep's fescue and sweet vernal grass, while the nitrate of soda has favored deeply-rooting grasses like the soft brome. Actual examination of the subsoil shows that the roots have penetrated much deeper on the nitrate of soda than on the ammonia plots; the roots having followed the soluble nitrate down into the soil in the one case, whereas in the other they remain near the surface where the nitrogenous material has been accumulated. We may apply the clue thus obtained to interpret the comparative results given by the two manures on other crops; wheat, for example, a deep-rooted crop, may be compared with barley, which feeds near the surface, and again with mangels, another deep-rooted crop.

TABLE XVI.—AVERAGE ROTHAMSTED CROPS.

	Average Yield.		
	Wheat. (22 years.)	Barley. (51 years.)	Mangels. (27 years.)
	Bushels.	Bushels.	Tons.
Complete manure—			
Nitrogen as nitrate ..	28·7	43·5	18·01
,, ,, ammonia .	23·4	42·1	14·86

It will be seen that with the deep-rooting crops, wheat and mangels, nitrogen in nitrate of soda gives a better return than an equivalent amount of nitrogen in ammonia salts, although other disturbing factors, such as lack of potash or lime, do not intervene; with barley, however, the yield is sensibly equal with the two manures. At the time of harvest, the crop grown with ammonia salts is always a little the riper; in the case of barley, this is of distinct value, for it results in a more uniform product of higher quality. With the mangels particularly it is seen that the plants manured with nitrate continue to grow long after those manured with ammonia salts have so completed their season's growth that the leaves are beginning to turn yellow and flaccid. All these differences are explained by the deeper rooting habit induced by the nitrate, the plant is less affected by the drought and the changes of temperature incident to autumn, growth is more prolonged, with the corollary of a larger yield but a later and less uniform maturity.

One other factor may also contribute to the general superiority of nitrate of soda. It must not be forgotten that when a nitrogenous manure reaches the soil there will be competition for it between the plant's roots and the mass of living organisms present in the soil, nearly all of which required combined nitrogen for their own development. Some of these organisms, like the nitrification bacteria, are wholly useful. Others cause permanent loss by liberating some of the nitrogen in the form of gas, but the majority simply withdraw the soluble nitrogen for a time from circulation, building it up in their own tissues. The immediate result is, however, a lessened availability of the manure, and this loss will fall far more upon ammonia compounds than upon nitrates, which are not so generally utilizable by the organisms found in the soil.

It is generally assumed that since nitrate of soda is not retained by the soil, whereas ammonia salts are, the former is a manure better suited to dry seasons and climates, whereas under wetter conditions there is less danger of the latter washing out of the soil. This view, however, forgets that if the ammonia salts are to feed the plant they must be nitrified, and that the calcium nitrate produced is just as likely to be washed down in a wet season. Indeed, the Rothamsted results do not bear out the popular idea. In exceptionally dry seasons there may be some advantage from the use of nitrate of soda because of the deep-rooted habit it induces, but the advantage is still more pronounced in seasons of excessive wet. Taking an average of the wet seasons against the dry, the ammonia salts do better in the latter. Probably the nitrification of the ammonia salts is checked in wet seasons when the temperature is low, and when also aeration is deficient through the repeated saturation of the soil.

It has been assumed that nitrification is a necessary preliminary to the utilization of ammonia salts by the higher plants, but this point of view is probably too sweeping. Mazé and other investigators have shown for laboratory cultures that plants may feed directly upon the ammonium radicle; and on the Rothamsted grass plots we have evidence that such an action is taking place on a large scale. It has already been mentioned that the soil of the plots constantly receiving ammonium salts has developed an acid reaction, on which, however, a luxuriant vegetation is still maintained. Yet the action of the nitrifying bacteria is suspended by a very small degree of acidity in the medium, and examination of these soils shows them to be almost devoid of nitrates down to the depth of three feet, and even incapable to giving rise to nitrification when seeded into a suitable medium. It is certain that in the soil of these plots nitrification, if not entirely suspended, is reduced to such small proportions that it cannot account for the nitrogen taken up by the crop.

The problems presented by nitrate of soda and sulphate of ammonia are so many and interesting that but little time is left for the discussion of the many important fertilizers in which the nitrogen is present as some organic compound. Of these fertilizers, Peruvian guano is perhaps the oldest and most widely known; news of the deposits was brought to Europe by Alexander von Humboldt in 1804, but it was in 1839 that a small consignment of two tons first reached Liverpool, to be followed the year after by a cargo. The demand increased so rapidly that by 1845 the shipments for the year had reached nearly 300,000 tons. The origin of the guano deposits will be considered in a later lecture; it is sufficient in this place to say that the proportion of nitrogen a guano contains depends upon the character, mainly upon the age, of the deposit from which it is worked. In the various grades in commerce the nitrogen will vary from as much as 18 per cent in the finest Chinchas guano, down to 2½ per cent in the so-called phosphatic guanos, the grade usually met with containing 6 or 7 per cent. The great virtue of Peruvian guano, which distinguishes it from most of the other fertilizers, is the varied state of combination in which the nitrogen is found; the original deposit probably contained little beyond uric acid and proteid nitrogen, but by the process of decay, which has already set in, a number of compounds have been formed, including as the following analysis (Table XVII.) shows, nitrates, salts of ammonia, urea, uric acid, and other more insoluble compounds of an organic nature. Thus while some of the nitrogen is immediately available, other compounds are less active and must undergo some bacterial change in the soil before they are ready for the plant. The plant is in consequence fed steadily and continuously without being presented with an excess of nitrogen at the earlier stages of its growth; furthermore, whatever changes of temperature and water supply take place to stimulate or check the growth of the plant, they will have a precisely parallel effect upon the bacterial changes which break down the compounds of the guano into plant food. It is found by experience that a plant supplied in this way with nitrogenous food, as it needs it, is generally healthier, and gives rise to produce of higher quality than one which has had an overplus of food in its earlier stages.

TABLE XVII.—ANALYSIS OF CHINCHAS GUANO, 1897.

	Per cent.
Nitrogen as uric acid	8·85
Organic nitrogen	2·98
Nitrogen as ammonia..............	3·94
Nitrogen as nitric acid	0·32
Total..............	16·09
Phosphoric acid—soluble	2·63
,, soluble in citrate..	6·29
,, insoluble in citrate	0·37
Total	9·29

Besides the true guanos, of which smaller supplies reach this country from some of the islands off the South African coast, there are a number of other products, the *débris* of certain food-preparing processes, sometimes called guanos, which agriculturally behave in a very similar fashion. For example, in the making of cod-liver oil and in various fish-curing processes, large residues of fish offal are obtained, which are desiccated, ground to a powder, and sold as fish guano. The percentage of nitrogen will vary from nine down to five, of phosphoric acid from five to ten. Similar products, known as meat guanos or meat meals, are prepared by manufacturers of meat extracts, tinned meats, etc., the whole of the animal not otherwise utilizable being dried and ground down. The composition of these meat products again will vary from as highly nitrogenous a material as pure dried blood with 12 per cent of nitrogen to mere bone meal with not more than 3 per cent. Another class of organic nitrogen fertilizers are of vegetable origin, the residue of seeds from which the oil has been extracted, and which for some reason or other are unfit for consumption by cattle. Of this class of bodies the best known here in England is rape dust, the meal from extracted rape seed, containing about 5 per cent nitrogen with about half as much phosphoric acid. In India and other tropical countries castor cake, the residue from which castor oil has been expressed, forms a good and cheap source of organic nitrogen. Another important class of nitrogenous fertilizers embraces all the industrial waste of manufacturing processes dealing with wool, silk, fur, and other materials of animal origin, but not, however, cotton, linen, or hemp residues, for they contain no nitrogen. In general these waste products are termed shoddy, and their composition is purely a matter of origin. Pure wool contains 18 per cent of nitrogen; shoddies having a woolen basis may contain as much as ten or as little as three per cent of nitrogen.

These organic nitrogenous fertilizers have each their own peculiarities, though they have never been studied in detail like sulphate of ammonia or nitrate of soda but they have certain properties in common. In the first place, they are more slowly acting and less available to the plant than the two manures just specified, the rapidity of their action depending both on their composition and their mechanical condition, especially the fineness of their division. Peruvian guano and dried blood would come at one end of the scale, material like ground hoofs and horns or leather at the other. The more slow acting a nitrogenous manure is the greater is the proportion that will be practically wasted, inasmuch as it will escape recovery not only in the crop to which it was applied, but in all succeeding ones. At Rothamsted, where farmyard manure is applied year after year, not more than 26 per cent of that applied to the wheat during the last fifty years has been recovered in the crop; where the crop has been mangels, the proportion recovered has reached 31 per cent. There is, of course, a great residue left in the soil of each of these plots; indeed, other experiments at Rothamsted show that after forty years some of the nitrogen applied as farmyard manure is still coming out in the crop. However, when the farmer has to wait as long as forty years he practically does not recover it at all, hence slow acting manures are inevitably wasteful. Various tables have been drawn up showing the relative activity of the various nitrogenous manures, but these we owe to continental observers and they are entirely based upon experiments in pots. For this purpose pot experiments are quite untrustworthy; the few existing field experiments tend to show that the activity and therefore the manurial value of these organic nitrogen compounds, even of such a material as shoddy, have been largely under-rated. The Rothamsted experiments upon barley and mangels would show that rape dust is almost as active a source of nitrogen as sulphate of ammonia, the crop recovering quite as high a proportion of the nitrogen applied; other experiments confirm this view based on long-continued trials by showing the effectiveness of rape dust in a single year's trial. Discounting, however, the prevailing false impression, there still remains the fact that these manures are, on the whole, more slow acting and less perfectly recovered in the crop than are nitrate of soda or sulphate of ammonia. Nitrogen for nitrogen they should be therefore less valuable, hence it is surprising to find that putting aside the shoddies, the unit of nitrogen always costs more in organic than in inorganic combination. What, then, is the origin of this strong prejudice of the farmer in favor of an organic source of nitrogen, a prejudice which is further seen in the common description of nitrate of soda and sulphate of ammonia as stimulants or even "scourges" of the soil rather than plant foods. Of course no purely nitrogenous substance is a complete manure, and cropping with one alone must eventually exhaust the land in phosphoric acid or potash, but as has already been shown, the reserves of such materials in the soil are so large, that long-continued cropping would be needed to deplete them seriously.

Some other source must be found for the farmer's prejudice, and its true cause is probably the manner in which organic manures improve the tilth of the soil, whereas sulphate of ammonia and particularly nitrate of soda injure it. The importance of this factor of tilth will be more realized when we remember that nearly the whole of the farmer's labor in spring is directed toward attaining a fine seed-bed for such crops as barley and roots. Furthermore, if the weather conditions are adverse to the start of the crop, the eventual yield will depend more upon the condition of the seed-bed than upon any other factor.

The potent effect of organic manures in promoting a good tilth is very clearly shown by the Rothamsted experiments upon mangels, where the nitrogenous manures are nitrate of soda, sulphate of ammonia, and rape cake respectively. In a good season the nitrate of soda is perhaps the most effective manure, but taking an average over the whole period, rape cake shows a great superiority, simply because of the difficulty of getting a full plant upon the other plots. Though all are cultivated in the same way and at the same time, the condition of the soil has become so bad where purely inorganic manures have been used, that only in favorable seasons is what a farmer would call a good plant obtained on the nitrate and the ammonia plots, whereas the rape cake plot crops regularly enough. On three occasions the plant has completely failed on the ammonia and nitrate plots. Even in the other years there are great deficiencies, as shown by the average number of plants counted on each plot.

TABLE XVIII.—ROTHAMSTED MANGELS, 1876-1902.

Plot.	Manures.	Average Crop per Acre.	Average Number of Roots per Plot.
		Tons.	No.
	Complete minerals		
4 C ..	with Rape cake	21·3	17·474
4 A ..	,, Ammonia-salts ..	14·9	14·802
4 N ..	,, Nitrate of soda ..	18·0	14·130

* From the Journal of the Society of Arts.

in ordinary farming, the effect upon the soil is never likely to become so pronounced as in these experiments at Rothamsted, but without doubt a considerable element in the extra value which the farmer sets on organic nitrogen must be put down to its improvement of the texture of the soil, a factor the farmer rightly regards as of the first importance.

(To be continued.)

EXPERIMENTS FOR DETECTING FOOD ADULTERANTS.*

By GILBERT H. TRAFTON.

EXPERIMENT 1. To Test Milk.

A. To Test for Formaldehyde.†

Place in a test tube 5 or 10 cubic centimeters of milk and add an equal quantity of strong hydrochloric acid and a piece of iron alum about the size of a pin head. Mix the liquids with a gentle rotary motion. Place the tube in a bottle filled with boiling water and allow to stand for five minutes. A purplish color of the mixture shows the presence of formaldehyde.

When the HCl is first added to the milk before the addition of the alum a pinkish tinge suggests the presence of a coal tar color.

B. To Test Milk for Borax or Boric Acid.

Dissolve 1 gramme of alum in 50 cubic centimeters of water and add 25 cubic centimeters of milk. Shake vigorously and filter. Pour about 5 cubic centimeters of the filtrate into a test tube and add five drops of hydrochloric acid. Dip a piece of turmeric paper into this solution and hold over the flame until dry. Place a drop of ammonia on the paper. A cherry red color before adding the ammonia and a dark green or greenish black afterward show the presence of borax or boric acid. The latter test is the better as an excess of HCl may cause the dry paper to become brownish red. (Turmeric paper may be made by dipping filter paper into a solution of turmeric powder in alcohol.)

Experiment 2. To Test Butter and Similar Fats.

A. To Distinguish between Oleomargarine, Rejuvenated Butter and Fresh Butter.

For the first test melt a small piece of the sample in a crucible cover, stirring with a splint of wood. Oleomargarine and rejuvenated butter sputter and boil noisily without producing foam, while real butter boils quietly and produces a large amount of foam.

For a second test fill a test tube half full of sweet milk with the cream thoroughly mixed, or skimmed milk may be used. Heat and add a teaspoonful of the sample to be tested. Stir with a wooden splint till the fat is melted. Cool the test tube by allowing the water from the faucet to run against the outside and stir the mixure till the fat hardens. If the sample is oleomargarine it will harden in one mass and may be lifted out on the splint of wood. If it is butter, either fresh or rejuvenated, it solidifies in granules scattered all through the milk in small particles. From these two tests you can distinguish between the three kinds of fat.

B. To Test Butter for Borax or Boric Acid.

Place a small piece of butter in a test tube and half fill with water. Immerse the tube in a bottle containing hot water till the butter melts. Stir the contents and cool the test tube with water till the butter hardens; then remove the rod with the butter adhering to it. Filter the liquid. Test the filtrate as directed for milk in Experiment 1B.

Experiment 3. To Test Meat Products, such as Sausage and Chopped Meat.

A. To Test for Borax or Boric Acid.

The sample should first be macerated with a little water and then strained through a white cotton cloth. The test may then be applied as directed for milk (Experiment 1B) or the liquid may first be clarified by cooling and filtering.

B. To Test for Sulphides.

Macerate the sample with water. Pour about 25 cubic centimeters in a flask and add pure zinc and about 5 cubic centimeters of HCl. If sulphides are present hydrogen sulphide will be liberated. To test for this, dip a piece of filter paper into a solution of lead acetate and suspend it in the flask. A black precipitate on the paper indicates the presence of hydrogen sulphide.

C. To Test for Artificial Coloring Matter.

This may sometimes be separated by macerating the sample with a mixture composed of equal parts of glycerine and water and a few drops of HCl. This is macerated for some time and filtered and then the filtrate tested for dyes as directed in Experiment 4C.

Experiment 4. To Test Fruit Products such as Jellies, Jams, Syrups.

A. To test for Salicylic Acid.

The test may be best made with liquids. Solids and semi-solids when soluble, should be dissolved in enough water to make a thin liquid. When insoluble they should be macerated with water and strained through a piece of white cotton cloth.

Pour about 50 cubic centimeters of the liquid thus obtained into a bottle and add a few drops of sulphuric acid. Shake for two or three minutes and filter into a small bottle. To this filtrate add about 25 cubic centimeters of chloroform and mix the liquid by a rotary motion, but avoid shaking. Pour the mixture into a beaker and allow to stand till the chloroform settles out in the bottom. By means of a pipette remove as much as possible of the chloroform (which dissolves the salicylic acid) without the other liquid. Place this chloroform in a test tube and add about an equal amount of water and a piece of iron alum a little larger than a pin head. Shake thoroughly and allow to stand till the chloroform settles to the bottom. A purple color in the upper layer indicates the presence of salicylic acid.

B. To Test for Benzoic Acid.

The sample is prepared as in the previous experiment for salicylic acid. Then proceed also in the same way to add a few drops of sulphuric acid, filter, add chloroform, mix, allow to stand, and remove chloroform with pipette. Place this chloroform in an evaporating dish or beaker and put in the hood and float on a dish containing hot water, and allow to remain till the chloroform evaporates. Or the dish may be placed outside on the edge of the window ledge. The presence of benzoic acid is shown by the flat crystals which may appear, which, on being heated, give off an irritating odor. This test is not a delicate one and can be used only when the acid is present in large quantities.

If tests are to be made for both salicylic acid and benzoic acid, the chloroform extract obtained from the sample may be divided into two portions and one tested for benzoic and the other for salicylic acid.

C. To Test for Artificial Coloring Matter.

Place a few teaspoonfuls of the sample in water and boil to dissolve it. Place in this liquid a small woolen cloth or a few pieces of white woolen yarn. Boil for 5 or 10 minutes, stirring occasionally. Remove the cloth and wash in hot water. If the cloth is brightly colored the presence of artificial dyes is shown. Natural colors give a dull pinkish brown tinge. To make the test more certain, place the cloth in a solution of dilute ammonia made by mixing 10 parts of water with 1 part of ammonia. Boil for about five minutes and remove the cloth. The artificial coloring matter dissolves in the ammonia. If this is colored add HCl to it till the mixture is acid. Place in it a fresh piece of white woolen cloth and boil. Remove and wash in water. If the cloth is colored, the presence of artificial dyes is shown. This may be a coal-tar derivative or a vegetable color. If the former, the cloth is usually turned blue or purple by the ammonia.

D. To Test for Glucose.

Pour a little of the sample into strong alcohol. If glucose is present, a white precipitate appears and settles to the bottom as a thick gummy mass.

Experiment 5. To Test Canned Vegetables such as Tomato Ketchup.

A. To Test for Salicylic Acid.

Proceed as in Experiment 4A.

B. To Test for Benzoic Acid.

Proceed as in Experiment 4B. The acid is frequently present in sufficiently large quantities to be indicated by this test.

C. To Test for Artificial Coloring Matter.

Proceed as in Experiment 4C.

Experiment 6. To Test Ground Coffee.

Spread the coffee out on a white piece of paper and examine with a magnifying lens. Chicory grains may be recognized by their dark gummy appearance, and cereal grains by their shiny polished surface.

Place a few teaspoonfuls of ground coffee in a bottle half full of water and shake thoroughly and allow to stand. Most of the coffee will float, while the chicory and cereal adulterants sink, coloring the water with a brownish tinge.

Some coffee substitutes will be found to contain some coffee if tested as just directed.

Coffee contains no starch, while most of the adulterants do. To test for starch boil the mixture a few minutes, allow to stand, cool, and add a drop of iodine. A blue color indicates the presence of starch and hence of some adulterant.

Experiment 7. To Test Spices.

A. To Test for Starchy Adulterants.

Cloves, mustard, and cayenne contain practically no starch, so that the presence of starch is proof of adulteration. To test for starch see the last part of the previous experiment.

B. To Test for Coloring Matters.

Artificial dyes are sometimes used with yellow and brown spices to restore the color taken away by other light-colored adulterants. Boil the sample in water to which a little HCl has been added. Filter and test as directed in Experiment 4C.

C. To Test Mustard for Turmeric.

If turmeric is present in large quantities it may be tested by adding a few drops of ammonia and some water to the mustard. A brown color shows the presence of turmeric. This test will not show the presence of small quantities.

Experiment 8. To Test Baking Powder for Alum.

Put some logwood chips in an evaporating dish and cover with water, and bring to a boil. Throw the water away. Do this three times but save the fourth solution. Fill a test tube about half full of water and add a teaspoonful of baking powder. Shake till effervescence ceases and add enough HCl to make the solution acid. To this solution add 4 or 5 drops of the logwood extract. A bluish red color indicates the presence of alum. A yellow color shows its absence.

Experiment 9. To Test Extracts.

A. Vanilla Extract.

Evaporate a quantity of the extract to about one-third its original volume. Add enough water to restore the first volume. The resins will be thrown down as a brown flocculent precipitate. If no precipitate is formed, no pure vanilla extract is present. If a precipitate is formed, add a few drops of HCl, stir, filter and wash with water. Dissolve the precipitate on the paper in a little alcohol. Divide this into two portions. To one add a piece of ferric alum, to the other a few drops of HCl. If neither produces more than a slight change of color the pure extract of the vanilla bean was used. If there is a distinct change of color, extracts from other sources are present.

B. Lemon Extract.

To a test tube nearly filled with water add a teaspoonful of the extract. If real lemon oil is present, it will be thrown out of solution and will give a turbid appearance to the solution and will form a layer on top of the water. If the solution remains clear after diluting with water, very little or no oil of lemon is present.

Experiment 10. To Test Olive Oil for Cotton-seed Oil.

Mix in a bottle or flask about 25 cubic centimeters each of the oil to be tested and Halphen's reagent. Place the flask in a vessel containing a boiling salt solution and heat for 10 or 15 minutes. A distinct reddish color indicates the presence of cotton-seed oil in small quantities, and a deep red, in large quantities.

(Halphen's reagent may be made by dissolving one-third of a teaspoonful of precipitated sulphur in 3 or 4 ounces of carbon bisulphide. This is then mixed with an equal volume of amyl alcohol.)

* School Science and Mathematics.

† For a more complete discussion of the methods of detecting food adulterants see SCIENTIFIC AMERICAN SUPPLEMENTS 1586 and 1587 for an article entitled: "Some Forms of Food Adulterations and Simple Methods for Their Detection."

In making these various tests for the first time, a little of the adulterant to be tested for should be added to the food being examined, so that the pupils may see what results follow when the adulterant is present. Then subsequent tests may be made with the foods as obtained.

GALERA, A LOST CITY OF THE CAMPAGNA.

FEW visitors to Rome are aware that there is a mediæval Pompeii within fifteen miles from the Porta del Popolo, a Pompeii, too, within easy reach of a wayside station on the line of the Viterbo. So when strangers from the capital arrive at the modest inn of S. Maria di Galera the few inhabitants of that commodious village appear surprised. Every now and again some member of the German college, which owns this modern Galera, comes out to inspect the place, and drives in at the archway, which still bears the arms of the great Borghese pope, Paul V. But if the new arrival be an Englishman, it is, of course, assumed that he has come to see old Galera or Galeraccia, "wretched old Galera," as the innkeeper's wife contemptuously but characteristically sums up the deserted town of the Orsini, where the great Emperor Charles V. did not disdain to dine when he was returning from his memorable journey to Rome—that journey which cost the city 200 churches and gave us the principal approach to the Capitol. As for the excellent hostess, she has lived here all her life, but has never taken the trouble to walk a mile to "Galeraccia." There is nothing to see there, she says; besides, she had heard from some daring explorer who had once been there that there were snakes in the rank grass. This piece of information was true; Galera is infested with reptiles; otherwise it would be an artist's paradise.

Here, in this bare Campagna, it would be impossible to find a finer site. Galera stands, or rather stood—for it is now all in ruins—upon a steep rock of tufa, the base of which is washed by the river Arrone on its course between the Lake of Bracciano and the sea. The stream is almost buried in overhanging bushes, and the walls of the mediæval town are scarcely visible for ivy and creepers. Not a sound is to be heard as we enter the gate, for no human being has lived here for a century, when malaria drove the last pale and gaunt peasants from their eyrie above the river to the less exuberant vegetation and purer air of S. Maria. Some of their mediæval monuments they took with their few household gods, chief among them the inscription, now in the church of the modern settlement, which records the consecration of the Church of St. Andrew by Cardinal Peter, Bishop of Porto, in the pontificate of Innocent III., and in the year of grace 1204. Occasionally they have used the old town as a quarry, but the people are few in these parts, and houses and walls are not much wanted, so that Galera has been left pretty much untouched. The arms of the Orsini still adorn the deserted town, which that great clan held for nearly five centuries; the belfry of one of the churches where they worshiped still stands, a prominent landmark from a distance; the remains of their palace are still visible, though the wild fig-trees are doing their best to tear the stones asunder. Nowhere, except down at Ninfa, in the Pontine marshes, is desolation at once so picturesque and so complete, and in both cases the cause has been the same. Yet these overgrown and almost impassable lanes have had a long and eventful history.

An anti-pope once sought refuge behind these ivy-clad ramparts, for it was here that Count Gerardo of Galera sheltered Benedict X., the nominee of the Roman nobles, from the assaults of the 300 Norman knights whom Nicholas II. and his great adviser, Hildebrand, had dispatched to the siege. The steep hillside and the stout walls proved too much for the Norman besiegers; but ere long the attack was repeated, and the count had to surrender his dangerous guest, who was sent to meditate in a monastery on the defective fortifications of Galera. Throughout the Middle Ages Galera shared the usual fate of the Campagna castles. As an Orsini stronghold it was, of course, sacked by their rivals, the Colonna; when Fortebraccio ("Strong-i'-th'-arm"), the great robber captain of the fifteenth century, descended upon Rome, Galera sent out a force of armed men to oppose him, and every important event which affected the prospects of its lords was doubtless reflected in the lives of the dwellers on this isolated rock.

Malaria has lost much of its terrors; quinine and wire-netting have made places habitable which not so

long ago would have been considered as veritable fever-beds. The Isola Sacra, near Ostia, is no longer deserted in the dog-days; there is talk of turning Castel Fusano into a watering-place; the colonists from Ravenna belie the pompous inscription in the courtyard of Cardinal della Rovere's castle, which bids the stranger "seek their scattered bones in the fields" (that inscription was the work of a Socialist deputy from the Romagna). But Galera is too picturesque and too circumscribed to entice its inhabitants back; nor is the fact to be regretted, for a deserted city is always most likely to be preserved.—Rome Correspondence of London Morning Post.

FALSE BACK REPETITION CASTING.

WHERE the cost of making plates is too great, or where facilities for preparing them do not exist, or where the number or price of castings does not warrant the expenditure incident to making proper metal plates, a very convenient and economical way of preparing a substitute is that of making false backs or copes in plaster, while as in most foundries one or more of the molders can do the necessary work, the thing comes out quite cheaply. Necessarily a little cost for time and plaster is involved, but this is a mere bagatelle as compared with the cost of properly made and fitted plates.

Properly, instead of using the copes of the boxes, wooden frames of the same size, and from 4 in. to 6 in. deep, should be used, as this saves considerably in regard to keeping the whole of the boxes in work, and as these should be made in sets of from six to two dozen, with all parts interchangeable, it will be seen that one or two frames will cover a large number of boxes of similar size.

While on the subject of molding flasks or boxes, it is well to point out that with the exception of special boxes for particular jobs, each size of box should be of uniform dimensions, and all parts should be interchangeable, so that boxes can be built up in several parts if necessary; or, on the other hand, each cope and drag will combine to form a separate box as occasion may require, the holes for the pins being drilled to a template, and the pins being held with nuts, this latter plan allowing two or more parts to be firmly bolted together should any job necessitate such a proceeding. Usually too little attention is paid to molding boxes, even where there is a lot of repetition work done, all

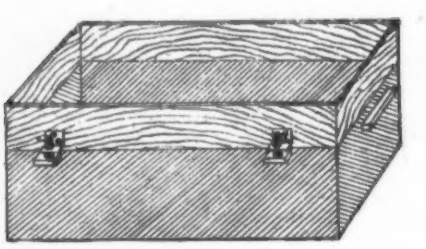


FIG. 1.

sorts and shapes being called on to keep the molders going. Loss of time and temper necessarily arises in such cases, while floor space is wasted very largely, and the latter point is often of importance, as space is not, usually quite unlimited. Besides, waste of floor space too often means that metal has to be hauled about all over the place, and instead of an orderly system of working one gets more or less general disorder. Of course, this is a matter that pleases some people, but it is not the thing which tends to the best or quickest working, and in these days the greatest economies are effected more by the saving of time and unnecessary labor than in the cost of materials. Anyhow, in a very large number of foundries, if the old boxes were scrapped and new ones put in their place, the saving would be a large one, while if the new boxes were in sets, with interchangeable parts, the total weight and number of boxes would be very appreciably reduced, and this particularly in the case of places where repetition work is largely carried on. Of course, the boxes should be designed so that they hold no more sand than is required for the particular class of work they are to be used for, and it should be borne in mind that fairly light boxes are more readily handled than heavy ones, although necessarily the kind of work done must at all times determine the actual size.

Coming back to our wood frames or dummy copes, these should be well put together, and iron bracket lugs should be firmly screwed on to take the pins in the drag. The arrangement will be as shown in Fig. 1, and the dummy cope should fit all the boxes of its particular size. Of course, where several sets of different patterns are to be used with one size of box, as many dummy copes will be necessary until the plaster back is destroyed in any one of them through there being no more of that particular set of patterns to be made, which, of course, ends the utility of that particular plaster back.

In preparing for this class of work, if large numbers of one particular article are required, one carefully-made wooden pattern should be made, with allowance for double shrinkage, and, if necessary, double machining will be necessary, and from this sufficient metal patterns will be made for the size of box that is about to be used. These patterns must be properly finished off, and must allow for one shrinkage, and machining, if any, as these are the actual patterns which will have to be used by the molders. As to the metal used for the patterns, this is optional; but usually ordinary type metal, or lead hardened with a sufficiency of antimony, will be good enough for a few thousand molds, but where greater numbers are needed—as in the case of malleable drive and elevator chain, for instance—brass would be the better metal. Either brass or white metal will, however, cast up clean if care is taken, and very little finishing should be required with good molding; but, of course, machining comes under rather a different heading, this being quite distinct from the finish left in molding.

Having these patterns, they should be arranged and bedded in the box in the usual way, with the sprues and gates laid on in wood strips; and then a drag should

FIG. 2.

be made in the ordinary way, ramming up hard, and finishing the parting very carefully. When done, the parting and the projecting parts of the patterns should be well and evenly dusted with ground steatite, or, if this is not to be had, plumbago will do, and the dummy cope put on, making the outside of the joint sound with a smear of soft clay. Well-mixed plaster should then be poured in, and the dummy cope made level on the top. When this has stood for a few hours, to set thoroughly, it should be lifted off and allowed to become dry, and then the face should be carefully cleaned, any holes filled, and when absolutely dry the face should have a couple of coats of shellac varnish, to make it really non-absorbent. When ready, the patterns should be dropped into their places in this false or dummy cope, the wooden sprues and gates—previously varnished with shellac varnish—put into position, and a drag rammed up for casting. The whole should then be turned over, the dummy cope removed, and a working cope rammed up in the ordinary way, and after this is lifted and the patterns, sprues, etc., withdrawn, the box should be closed and cast, when, if the work has been properly done, there should be no alterations required and the whole arrangement should work smoothly and well.

Where patterns are undercut—as with the hooks of drive chains, for instance—if the core prints do not permit of their leaving the plaster readily, the use of ordinary beeswax will have to be resorted to for the purpose of filling out those parts which are likely to be in the way for free lifting of the dummy cope, but generally this is not needed.

Properly made, these dummy copes will cause the use of the trowel and cleaner to be much reduced, and will also expedite the work to such an extent as to enable a man to do three or four times the amount of boxes he could do without the dummy, but, of course, this largely depends on the inclination of the molder.

Where there is any fear of the plaster back falling from the wood frame, a bead or fillet should be run round inside, as shown in Fig. 2, this being all that is needed for the smaller sizes, but where boxes of large area are being dealt with it is also necessary to have wooden backs to support the plaster, as shown in Fig. 3, as in ramming the sand in the drags a goodly amount of pressure may be made to come on the plaster, and, this initially not being a very strong material, will readily break if too much pressure is put on it, unless it is cumbrously thick, a point which

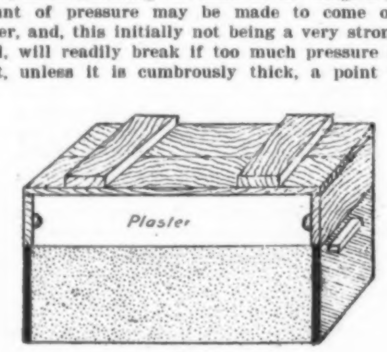


FIG. 3.

tells greatly against convenient handling.—The Practical Engineer.

The harbor of Honolulu has been dredged to a uniform depth over all of 35 feet, and the entrance channel widened by 150 feet. The new slip, alluded to in a recent report, has been excavated with a depth between mean low tides of 34 feet. The wharf floors flanking it are also laid in cement, so that there only remains to erect the proposed "double-deck" shed for the present large freight and passenger service. A large shed has also been built in connection with the quarantine island, for the convenience of infected vessels. The Federal government has lately appropriated a large sum of money toward building a breakwater at Hilo, in Hawaii, and this should induce a marked increase in shipping and trade at that port within the next two years, with the certainty that Hilo is to be the main port of that island. While that point was undecided, capital for needed railroad development in that region hesitated to a considerable extent, but now the decision of the United States government experts has become known, the development of the Hamakua Railroad becomes a probability.

PRACTICAL TESTING OF RUBBER.

THIS material in the form of sheeting, valves, etc., occupies an important place in the materials, odd and otherwise, that the present-day machinist and engineer are called upon to use. Its price—which rises steadily year by year—does little to deter its rapidly extending use, as no efficient substitute has been found having the peculiar characteristics it possesses; wide application is probably the principal factor enhancing the price. The methods of collection are primitive, and the supply cannot keep pace with the demand.

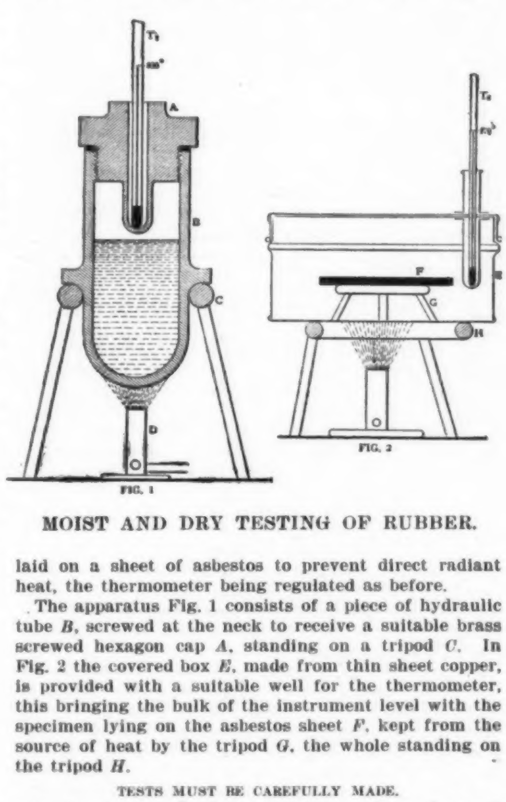
The finest gum—known as Para—is so high in price that it is increasingly difficult to obtain manufactured material having this gum as its elastic ingredient. Makers tend to use a proportion of re-manufactured material, which is never so satisfactory as the South American gum, and should consequently be rigidly barred, where rubber has important duties to fulfill.

Compositions differing in their constituents, all known as rubber, are satisfactory when used for the particular purpose for which they have been made. But good results cannot be looked for unless first-hand rubber is used, as a large percentage of the whole. As these formulas of composition concern the actual makers more than the users, they are omitted. But a test to which all kinds of good class rubber can be subjected is available to the possessor of some easily constructed apparatus. The test is applicable to any rubber, whether partly combined with canvas or without.

THE APPARATUS USED.

Referring to the sketches, the apparatus is not elaborate and with modifications could easily be made in the average machine shop. The tests are: (1) Subjecting a sample to a moist heat of 320 deg. F. for four hours; and (2) a dry heat of 270 deg. F. for two hours on another sample.

In order to obtain (1) pressure must be provided for. Fig. 1 shows the receiver filled partly with water. The sample is put in, the cap screwed down, and the thermometer placed in position, the gas burner being regulated by hand to give and regulate the temperature required. Fig. 2 shows the dry test. The sample is



MOIST AND DRY TESTING OF RUBBER.

laid on a sheet of asbestos to prevent direct radiant heat, the thermometer being regulated as before.

The apparatus Fig. 1 consists of a piece of hydraulic tube *B*, screwed at the neck to receive a suitable brass screwed hexagon cap *A*, standing on a tripod *C*. In Fig. 2 the covered box *E*, made from thin sheet copper, is provided with a suitable well for the thermometer, this bringing the bulk of the instrument level with the specimen lying on the asbestos sheet *F*, kept from the source of heat by the tripod *G*, the whole standing on the tripod *H*.

TESTS MUST BE CAREFULLY MADE.

Constant supervision is essential to keep the temperature required, as a slight excess renders the test unfair and valueless.

When the samples are removed after the test, no appreciable loss of elasticity should be found, and the rubber should not be ruined. A slight discoloration is not detrimental.

A shop having steam pressure available should be able to rig up so as to require only occasional supervision for the wet test, steam at 75 pounds absolute corresponds for temperature. A length of pipe fitted with a reducing valve, suitably loaded, and a steam trap should be effective. A firm purchasing quantities of rubber-joining material would find the small outlay involved by the tests amply repaid, as it enables reliable stuff to be purchased in the cheapest market.

It has proved itself valuable even in checking first-rate makers of rubber goods using the best materials. So far from being too severe a test for commercial material, it is in daily use, and if the test is stated when ordering, no difficulty should be found in purchasing.

Finally, it is believed that rubber to stand the tests cannot be made of re-manufactured material, and the cheaper and less satisfactory gums are excluded, making it necessary to use only Para rubber as the principal ingredient in the compositions termed commercially rubber; as if its use is known to the makers, and the supply stands these tests, satisfactory results are obtained.—American Machinist.

WIRELESS SIGNALING SYSTEM FOR RAILROADS.

Several forms of radio-telegraph railroad signaling systems have been proposed and a number of tests have been carried out with only partial success. As an improvement in such a system Mr. Frank W. Prentice of Chicago has been granted a United States patent, No. 843,550, on an invention which relates more particularly to cab and block-signal systems employing Hertzian waves for controlling signal devices upon a car or engine to indicate the conditions of the right-of-way with respect to the presence or absence of other vehicles or with regard to any of the usual conditions of danger or safety of the track within prescribed limits.

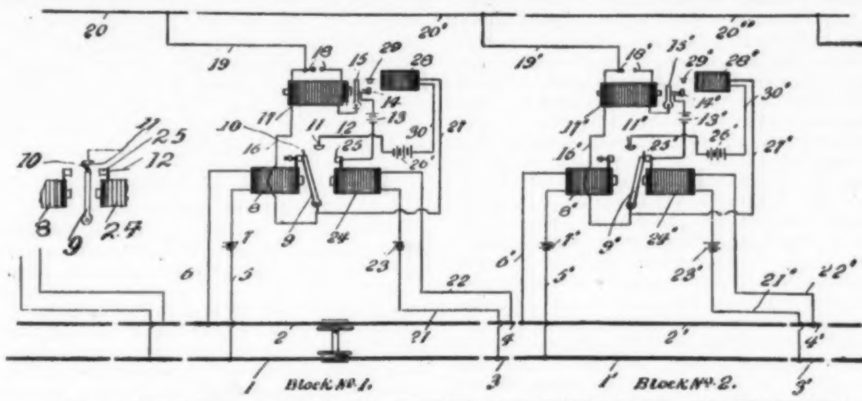


Fig. 1.—WIRELESS SIGNALING SYSTEM FOR RAILROADS. DIAGRAM OF SECTIONAL CAB AND BLOCK SIGNALS.

To this end the invention comprises a generator or transmitter of electrical oscillations for each block or section of the road, which is normally operative when conditions of safety maintain in the block or section to be guarded, and is rendered inoperative or inert when conditions of danger exist, and receivers on the cars or engines influenced by the oscillations and adapted to control signal devices which indicate whether the section is "safe" or "blocked."

Generally the invention comprises a cab and block system in which "safety" is indicated in a given block by the generation of oscillations in the transmitter controlling such block and in the car or cab by signal devices controlled by a receiver influenced by such oscillations, and "danger" is indicated by the absence of such oscillations and a consequent non-action of the receiver in the car or cab.

In the accompanying drawings, Fig. 1 is a diagrammatic representation of a sectional rail cab and block signal system embodying the invention upon the east-bound track of a double-track railroad. The small drawing at the left is an enlarged fragmentary detail of the track relays and the contacts controlled thereby.

Referring to Fig. 1, (1) (2) and (1') (2') indicate the rails of two adjacent blocks or sections into which the track is divided, the sections being designated "Block No. 1" and "Block No. 2," respectively. It will be understood, of course, that the west-bound track is similarly equipped, the apparatus being in reverse position to that shown in Fig. 1. In using a single track or line of road for moving trains in both directions on the one track or line of road, each side of the track is equipped with apparatus, as shown in Fig. 1, one on one side for west-bound and on the other side for east-bound trains. The entire track or road is similarly divided into blocks or sections of any desired or prescribed length, each block defining the limits within which but one train is allowed at one and the same time under proper conditions of operation, as will be understood by those skilled in the art.

Bridging the rails (1) and (2) of block No. 1 is a magnet (8), connected to the respective rails by wires (5) and (6), and including a battery (7). The magnet (8) controls a pivoted armature (9), which normally engages a contact (25), forming one terminal of the circuit of an emitter or generator of Hertzian waves or electrical oscillations (17), which circuit includes a conductor (12), battery (13), back contact (14), and armature (15) of induction coil (17), and wire (16), which leads from the other terminal of the induction coil (17) to armature (9).

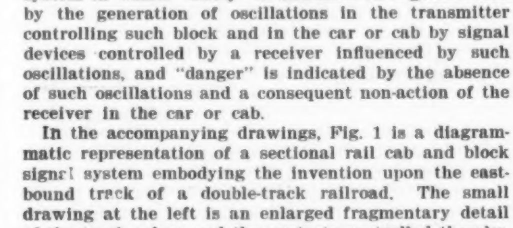


Fig. 2.—COHERER OF WIRELESS SIGNALING SYSTEM FOR RAILROADS.

When block No. 1 is not occupied by a car or train, armature (9) is attracted from magnet (8), closing the circuit through the induction coil or transmitter (17), and sending a series of electrical oscillations generated at the spark-gap or terminals (18) of the secondary by way of conductor (19) to an overhead wire or conductor (20), paralleling and coextensive with the track section or block in rear of block No. 1. As long as block No. 1 is unoccupied these oscillations are generated and conducted along the wire (20), which serves the same purpose as the ordinary aerial to indicate upon any train or car entering the rear section by apparatus to be hereinafter described that a condition of safety maintains in block No. 1. When a train or car occupies block No. 1 the wheels of the train bridging rails (1) (2) close the circuit of battery (7), which energizes magnet (8), which attracts armature (9), thereby opening the circuit of the induction coil and stops the generation and propagation of electrical oscillations by said induction coil along conductor (20), so that a train entering or occupying the section in the rear of block No. 1 receives no oscillations, and the operator is apprised of a condition of danger existing in block No. 1.

Block No. 2 is provided with a like installation of electrical apparatus by means of which electrical oscillations are generated and propagated along a conductor (20), paralleling block No. 1 as long as block No. 2 is unoccupied, and the oscillations are discontinued when block No. 2 is occupied to indicate upon a car or train in block No. 1 that the former block is at "danger." Similarly each other block or section is equipped to send oscillations along a wire paralleling the next block in the rear to indicate "safety" and to suppress the oscillations to indicate "danger."

It is to be particularly noted that the arrangement of the track and the generators or emitters of electrical oscillations controlled thereby, so that the existence of oscillations shall indicate "safety," and the absence of such oscillations shall indicate "danger," through the agency of any suitable receiver or responsive apparatus upon a car or train, constitutes a complete and effective signaling system.

It is also to be observed that the combination of a track divided into blocks or sections with an emitter or generator of electrical oscillations in each section, and receivers or responsive devices on the trains or cars operating on the track is generically within the purview of the invention, provided the presence of oscillations in a given section shall indicate "safety" and the absence thereof shall indicate "danger," even though the control of the oscillations be effected by means other than track or rail circuits—as, for example, when an emitter or generator for a given block or section is controlled by the relative position of a semaphore, a switch-operating mechanism, a drawbridge or any other apparatus or appurtenance of a railroad to generate oscillations when the way is safe, and to suppress such oscillations when it is dangerous for an oncoming car or train to proceed beyond the next advance section.

Each car or engine is provided with a suitable receiver or responsive device which operates under the influence of the Hertzian waves or oscillations to effect a predetermined signal or indication on the car or engine. Such receiver and signal may be of any of the usual co-ordinations of Hertzian-wave receiving devices—such, for example, as an ordinary coherer and signal circuit controlled thereby—which operates to close a local circuit to actuate the signal when a Hertzian wave traverses or affects the coherer, and to open the circuit and discontinue the signal when the Hertzian waves or oscillations cease or are interrupted, it being understood that the continuance of the signal or indication due to the transmission of the local circuit through the coherer, which latter is rendered operative by the Hertzian waves, signifies a condition of "safety" as to the guarded block or section, and the discontinuance of the signal by the interruption of the current at the coherer indicates a condition of "danger."

Fig. 2 is a fragmentary perspective view of a coherer or wave-responsive device and appurtenant apparatus. The coherer (40) consists of a generally cylindrical body having in two diametrically opposite faces recesses (41) and (46), each covered by a suitable cap or cover of glass or similar material. In (41) is placed suitable metal filings or other material that is responsive to ethereal waves, which cause the filings to cohere and transmit an ordinary voltaic current, but which when subjected to a slight jar or alteration in their relative positions interpose so high a resistance as to fail to transmit such voltaic current. Traversing the cylinder (40) and having their inner terminals imbedded in the filings in recess (41) are two conductors which are connected with contacts on the ends of the cylinder, the contacts being adapted when recess (41) is uppermost to be engaged by brushes, which are connected by wires with a relay. Recess (46) is partially filled with some material that is normally conductive of voltaic currents, such as mercury or the like, and two conductors lead from the lower part thereof to two contacts on the ends of the cylinder (40), which when recess (46) is uppermost are engaged by brushes which connect by wires a magnet through a suitable battery to engage said magnet.

The cab signaling device operates as follows, as shown in Fig. 3, which is a diagram of the apparatus on each car or cab: When the car or engine occupies a block—as, for instance, block No. 1—and the adjacent block No. 2 is unoccupied, the Hertzian waves transmitted along wire (20') (Fig. 1), and radiating from the wire through the air pass through and energize the coherer (40), closing the circuit of relay (57), which closes the circuit of magnet (56), causing the armature (54) to move to the right and rotating the coherer (40) through 180 degrees, thereby disturbing the filings in (41) (Fig. 2), breaking the circuit of relay (57) and de-energizing magnet (56). Recess (46) (Fig. 2) is thereby brought uppermost and the circuit of magnet (55) is momentarily closed, attracting armature (54) and returning the coherer (40) to its original position.

As the coherer cylinder rotates the passage way in the compressed air valve controlled by the coherer is opened and air is admitted from tank (70) to bellows (75). As the coherer is rapidly rotated or oscillated to and fro by the recurrent action of magnets (55) and (56) as the material in (41) is successively cohered and decohered, air pressure quickly accumulates in bellows (75), and the latter is inflated, causing the red or danger glasses to be moved out of registry with lenses (86) and (87) and showing a white or safety light.

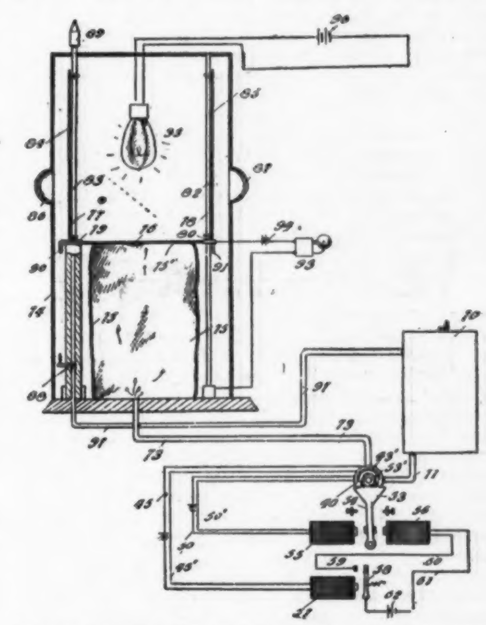


Fig. 3.—WIRELESS SIGNALING SYSTEM FOR RAILROADS. DIAGRAM OF APPARATUS ON LOCOMOTIVE CAB.

This condition will maintain as long as block No. 2 is clear, and the Hertzian waves are sent out by induction coil (17'). Should the operation of induction coil (17') be suspended by the presence of a car or train in block No. 2, and no waves be sent along wire (20'), the coherer (40) would cease to operate, but would assume the position indicated in Fig. 2, and air pressure from tank (70) would be shut off from bellows (75). The air in the latter would escape through valve (75') and the bellows would deflate, causing the red glasses (86) and (87) to cover lenses (86) and (87), showing a red or danger signal. When the bellows are nearly deflated, valve (88) will be opened by detent (90), admitting air to whistle (89), causing the latter to sound a danger signal, and contact (91) engaging contact (92) will close the circuit of bell (93), giving an additional audible danger signal to warn the operator to stop his car or train until the succeeding block is clear, to be evidenced by the coherer again taking up its operation, due to the restored oscillation, and setting the visual signal at "safety" and discontinuing the operation of the whistle and bell.—Western Electrician.

WORLD'S MARCONI STATIONS.

The wireless telegraph stations of the world have been located and catalogued by the Bureau of Equipment of the Navy Department of the United States, and the lists will shortly be published in book form. The number of stations in each country are: Belgium 1, Denmark 4, Germany 13, France 6, Great Britain and Ireland 43, Holland 8, Spain 4, Portugal 1, Gibraltar 2, Italy 18, Malta 1, Montenegro 1, Norway 1, Austria-Hungary 2, Roumania 2, Russia in Europe 8, Sweden 3, Turkey 6, Argentina 5, Brazil 5, Canada 5, Chili 1,

Costa Rica 1, Mexico 2, Panama 2, Uruguay 1, United States 88 (10 of which are located in the United States possessions), Trinidad 1, Tobago 1, Andaman Islands 2, Burma 1, Hong Kong 1, China 5, Hawaii 5, Japan 2, Dutch East India 5, Russia in Asia 1, Egypt 2, Morocco 2, Mozambique 2, and Tripoli 1.—Canadian Engineer.

THE UTILIZATION OF WASTE INDIA RUBBER.*

By WALTER F. REID, F.I.C.

To the chemist there is in reality no waste; it is simply a matter of expediency whether and in what way any substance shall be utilized. The waste product of one industry forms the foundation of subsidiary industries, and it not infrequently happens that the by-product replaces its parent or becomes the mainstay of the manufacturer. In this connection, some of us can still remember the time when coal tar was an objectionable by-product, difficult and costly to dispose of; the chlorine products of the Leblanc soda process render competition with the ammonia process possible, and we have explosives manufacturers erecting soap works for the sake of the glycerine which was formerly poured down our sewers in enormous quantities. It is, in fact, a rare occurrence that a new industry is started without the production of some by-product for which a use has to be found.

It is not often that the industry producing the by-product is the only outlet for its own waste, as is the case with india rubber. In this instance, practically the whole output becomes, sometimes in a very brief space of time, a waste product. In some cases, as with motor-car tires, mechanical deterioration takes place long before chemical changes cause disintegration; but in others oxidation of the material renders it unfit for its original purpose.

For many years, especially while abundant supplies of crude rubber were obtainable at moderate prices, little attention was paid to waste rubber, although as early as 1846 it was recognized that such waste might be utilized with advantage, and Parkes laid the foundation of the alkaline method of recovery. Of late years, however, there have been remarkable developments in the india rubber industry. The increased demand, mainly due to electrical progress and improved methods of locomotion, has more than equaled the immediately available sources of supply, and the result has been a considerable increase in price. The total production of rubber last year was about 68,000 tons, and the increase in the annual output has been about 15,000 tons in five years. As bearing upon the quality of the material, it will be interesting to ascertain the chief sources of supply. America easily leads the way with a production of 42,800 tons, of which 41,000 tons, or nearly two-thirds of the whole quantity harvested, is credited to Brazil. Much has been said and written lately about the production of rubber in Mexico, and considerable amounts of American capital have been invested in "Guayule" rubber; but last year the whole production of Mexico only amounted to 200 tons, so that the quantity of this low-class rubber is not yet of importance. It has been calculated that only about 300,000 tons of the shrub "parthenium argentatum" from which "Guayule" rubber is extracted are available, and, with a yield of 6 per cent of rubber, this quantity would only produce about 18,000 tons of rubber.

Africa comes next as regards quantity, the output being 23,400 tons. The Congo Free State is here the largest producer, having brought 4,500 tons into the market. In view of the methods by which this rubber is obtained, it can scarcely be expected that the production will be materially increased in this district. Germany is devoting much attention to rubber in her African colonies, and will soon be producing plantation rubber.

The rubber derived from Asia and Polynesia is estimated at 1,800 tons per annum; but this quantity will probably increase rapidly within a few years, and no doubt "plantation" rubber will in time displace "Para" from its premier position as regards quality. Some of the rubber sent to us from plantations in the East is of excellent quality, quite equal to the best "Para," and very free from impurities; but many of those who grow the rubber are not sufficiently informed as to the requirements of the user, and there is here a wide field for the trained chemist, as compared with the chemical inventor who has not been trained. It is estimated that trees already planted should, in about ten years' time, yield some 25,000 tons of rubber per annum; but too little is known of the influence of climate, soil, and diseases of the trees to make this a reliable estimate.

The great bulk of rubber produced is of good quality, and, if it went into consumption in the state of purity in which it is received by the manufacturer, the average quality of the waste would also be high. Unfortunately, however, substances of the most varied properties are added during the process of manufacture. Mineral matters of various kinds sometimes make up the greater part of the weight of what is sold as india rubber, while the rubber itself is largely replaced by substitutes, generally consisting of some form of solidified oil. One ingredient, however, is common to nearly all forms of manufactured rubber, and it is this that has proved the stumbling block to most inventors who have endeavored to utilize rubber waste. I refer to the sulphur used in vulcanizing, part of which enters into chemical combination with the rubber, and which is very difficult to expel again without injuring the quality of the material. Vulcanization is at present a necessity, for no other process has yet been discovered which renders rubber so inert to changes of temperature. Once the vulcanization has taken place, however, the cut surfaces of rubber will no longer adhere to each other, and the material cannot be worked into a homogeneous mass. It is probably the sulphur that is the cause of the disintegration of rubber, because crude rubber will keep for a number of years without deterioration. Here is a piece of crude Para rubber sixty-five years old. It was bought in Glasgow in 1842, weighs one ounce, and cost 2s. 6d., and is practically in the same state now as then. The other piece of raw rubber came into my possession in 1861, and is also in quite good condition. The best sample of vulcanized rubber I have met with is a red rubber stopper now twenty years old; but, as you will observe, it has become quite brittle outside, although still soft inside. Nearly all old vulcanized articles contain traces of sulphuric acid, due to the gradual oxidation of the free sulphur, and this is probably the main cause of the deterioration. Rubber which has become brittle through age cannot be regenerated by any of the processes at present in use, and is practically valueless. In many cases, however, rubber articles have to be discarded long before chemical disintegration sets in. Motor-car tires and shoes are worn out by attrition, sometimes in a very short time, and yield valuable material for the industry we are discussing. The inner pneumatic tubes of bicycles and motor cars are the best waste available on a large scale; but, as they can be utilized by grinding and mixing with fresh rubber without undergoing any chemical process, they command a relatively high price. Manufactured rubber contains mineral matters of various kinds, known as filling materials or compounding materials. The most frequently used are calcium carbonate, calcium sulphate, magnesium carbonate, magnesia, barium sulphate, zinc oxide, litharge, white lead, china clay, French chalk, and lithopone.

In regenerating rubber, it is not necessary to remove all of these; but their presence naturally diminishes the value of the product obtained. Perhaps the most troublesome impurity in rubber waste is fiber derived from the fabrics which so frequently form the basis of rubber goods. In a motor-car tire, for instance, there may be eight or ten thicknesses of fabric in about half an inch. The best method of removing fiber is the mechanical one, as this does not deteriorate the quality of the rubber. The whole mass is ground into a coarse powder which is then exposed to a current of air by means of which the fibers are removed, and the rubber is left behind. The separation is only partial; but the removal of the fiber is generally complete enough for practical purposes.

There are, however, some materials in which the fiber is so intimately incorporated with the rubber that it cannot be separated by mechanical means. In such cases, the grinding is continued until the fiber is reduced to a powder which remains in the recovered rubber, or the fiber is destroyed by chemical means. The chemical reagents used differ according to the nature of the fiber. Vegetable matter is destroyed by treatment with an acid, generally sulphuric acid, or an acid salt, followed by heating. The decomposed fiber can then be washed out, together with such mineral matter as is soluble in the acid used. For the destruction of animal fiber, such as wool, an alkaline solution is preferable, followed by drying and subsequent washing. Although india rubber is less acted upon by both acids and alkalis than the fibers with which it is mixed, yet there is always sufficient action to deteriorate considerably the quality of the recovered product. Innumerable attempts have been made to recover rubber by dissolving the waste in a suitable solvent; but most of these have failed, owing to the fact that vulcanized rubber becomes insoluble in the usual solvents for raw rubber. It will swell in many liquids; but will not dissolve until such a degree of heat is applied that the rubber itself is decomposed. Vulcanized rubber can be converted into a homogeneous mass by superheating; but this causes a decomposition of the rubber itself, and, although the product can be used in admixture with fresh rubber, and has even great cementitious powers, it is very deficient in elasticity and tensile strength. Many of the varieties of recovered or regenerated rubber in the market are in reality overheated, while some are overworked.

There are many liquids which will lixiviate part of the free sulphur from the vulcanized material; but in most cases their use involves a permanent deterioration of the rubber, which still retains the bulk of the free and practically the whole of the combined sulphur.

Last year M. A. Tixier, a French chemist, made the interesting observation that vulcanized rubber was completely soluble in terpineol. Upon this fact, a process for the regeneration of waste rubber has been based, the patent specification for which was recently published. (Fr. Pat. 370,619, October 19, 1906.) The rubber, whether vulcanized or not, is reduced to pulp and digested with twice its weight of terpineol in a closed vessel fitted with an agitator. The temperature specified is 100 deg. to 150 deg. C. The solution thus obtained is agitated with four times its volume of benzene. Insoluble impurities subside, the clear liquid is decanted, and the benzene distilled off. The rubber is then precipitated by the addition of alcohol or acetone. Regenerated rubber obtained in this way resembles the natural product more than any other kind that I have seen. It is very viscid, and will stand a large admixture of neutral mineral substances. It can be revulcanized and possesses considerable power of resistance to chemical reagents. This latter quality is probably due to the fact that the method of preparation eliminates the resinous impurities of the rubber which are most readily attacked by acids or alkalis.

In spite of the poor quality of the rubber recovered by the old processes, the trade in this article is considerable, especially in the United States. No less than 10,600 tons of waste rubber was imported into that country last year. The recovered rubber exported amounted to 380 tons, of which Great Britain took 211 tons. Our home production of recovered rubber is considerable, but official statistics are not available.

Waste rubber is sorted into about a dozen different grades, which vary in price according to the quality of the rubber which they contain and the greater or less difficulty of extracting.

* Journal of the Society of Chemical Industry.

BACTERIA IN CHEESEMAKING.*

By PROF. HERBERT W. CONN.

IN regard to the relation of micro-organisms to cheesemaking, we know as yet less than about their work in buttermaking, and the practical applications have hitherto not been extended. It is certain that the relation of bacteria to many problems of cheese ripening is very intimate, and that further studies will disclose facts that we do not now know. It is, also, fairly certain that practical applications of bacteriology to cheesemaking are sure to come, and many phases of this industry are to be modified in the not far distant future by new discoveries. Already some practical results have been obtained, and the present time is seeing a large knowledge both obtained and practically applied to cheesemaking.

There are many different kinds of cheese, and no two types are made in the same way, have the same history, or are ripened by the same agents. Each special kind of cheese has to be studied by itself, and it is difficult to make any general statement concerning the relation of micro-organisms to cheesemaking. Moreover, it is quite certain that some of the phenomena of cheesemaking and cheese-ripening concern other factors besides the growth of bacteria or similar agents, and we do not, as yet, know to what extent cheese-ripening is due to the growth of micro-organisms. A few facts, however, are now well proved and may be briefly summarized.

The relation of bacteria to cheese, if they have any relation at all, is to the phenomena of the ripening of the cheese. The green curd, when first made into a cheese, has no cheese flavor, is hard and tough, and, in general, not an appetizing product. It is, however, ripened for a varying period, during which time the chemical nature is undergoing changes, and the cheese becomes more easily digestible and changes it flavor. It is the latter fact, the change in flavor, which is of the highest importance in rendering cheese a favorite market product, and in which in all probability micro-organisms are in some degree concerned. As yet, however, we do not in many cases know to what extent cheese flavors are due to the action of bacteria.

It is certain, however, that in nearly all types of cheese the first phenomenon which occurs, and which appears to be quite necessary to all subsequent ripening, is the souring of the curd. We have already learned that this development of lactic acid is dependent wholly on the growth of bacteria; hence, the first process of cheese ripening is bacteria growth. For this reason, it has become evident that to make a high-grade type of cheese, it is necessary that the milk should contain a sufficient quantity of favorable lactic bacteria. We have already learned that there are two types of bacteria which produce lactic acid, one producing gas, and the other producing no gas. Cheesemakers have learned to their sorrow that the presence of gas-producing organisms, in any considerable quantity, is fatal to the production of a good quality of cheese. Great quantities of cheese are entirely spoiled by the growth of the gas-producing organisms. These facts have been appreciated only in recent years, and now cheesemakers are adopting various methods of checking the growth of gas organisms. Among other methods there is now being more and more widely adopted the use of pure cultures of lactic germs, to be added to the milk for the distinct purpose of controlling the souring as a preliminary to cream-ripening. Cheesemakers are to-day learning to control their ripening by the purchase of lactic cultures from dealers, and their inoculation into milk. This method has been developed in the last few years and seems likely to continue to extend widely. The inoculation of a large quantity of lactic bacteria helps greatly in holding in check the development of the gas-producing organisms, as well as of other bacteria which might produce trouble. Here, then, is the first practical application of bacteria to cheesemaking.

IN EDAM AND SOFT CHEESES.

It is interesting to note that even before bacteriologists understood facts concerning the relation of bacteria to cheese there had been made a practical application of the bacteria to the manufacture of one variety, the well-known Edam cheese of Holland. For quite a number of years it has been known that the manufacture of this cheese could be hastened and rendered more uniform by the use of a starter added to the milk, known as "slimy whey." This is a whey or milk in which certain species of bacteria have developed until there has been produced a decided sliminess. An addition of a proper quantity of this starter to the milk results in a decrease in the time of ripening of the cheese, and in a somewhat greater uniformity in the product. There is no improvement in the type of

* The Country Gentleman.

cheese, but only in the uniformity and quickness of ripening. This slimy whey has been used extensively in Holland, and its use has been increasing rapidly in the last fifteen years. It was a practical application of bacteriology to cheesemaking by a method discovered before it was known that bacteria had any special relation to the matter. It should be stated, however, that in spite of all investigations, at the present time the exact relation of bacteria to the ripening of the Edam cheese is unknown.

Somewhat more is known concerning the relation of micro-organisms to the manufacture and ripening of soft cheeses and semi-soft cheeses. Among the former class are the Limburger, the Camembert, and the Brie types, and among the latter the Roquefort and Gorgonzola. These types of cheese are very popular abroad, and they represent quite a different kind of ripening from that of the better known hard sorts. They represent also, in general, a type of fancy cheese, which has a smaller market than that of the hard cheese, and which commands a higher price. In the last five years considerable information has been discovered concerning these cheeses. As would be expected by any one who knows the great difference between them, it has been found that they are not ripened by similar agents or under similar conditions. It may be stated, in general, that some of them owe their distinctive characteristic, primarily, to the growth of molds.

This is true of the Roquefort and Gorgonzola, and the English Stilton cheeses. Others of this class owe their characteristics to a combination of a development of molds and bacteria-growing in connection with each other in certain peculiar relations. This is true of the Camembert and the Brie type; others, again, appear to be ripened primarily by the action of bacteria or allied low types of organisms, among which may be placed the Limburger. In these types of cheese the course of the ripening has been so thoroughly studied, and is so well known, that there is no doubt that the primary agents are micro-organisms.

As a practical result of these discoveries the manufacture of soft cheeses is becoming more and more of a scientific process. Up to within a few years their production has not been understood, and it was known that certain types would not be produced equally well in different localities. Many vain attempts have been made to manufacture in the United States some of the soft cheeses common in Europe. The failures have been attributed to all sorts of conditions; but it now seems to be in a large degree due to the fact that the proper micro-organisms are not found in American dairies. At the present time, these organisms are being introduced from their proper localities, and there is beginning in this country, as well as in Europe, a scientific manufacture of the soft cheeses. This industry has not, as yet, been in existence long enough to have demonstrated its possibility as a financial success. It has, however, been shown beyond peradventure that it is perfectly possible to manufacture the soft cheeses in the United States as well as in Europe, using the types of milk, the types of cow, and the climate of this country, and obtaining products identical with and indistinguishable from the best products in Europe, provided the proper micro-organisms can be introduced into the cheese in the proper way.

There seems to be little doubt that future development along these lines will show the possibility and feasibility of an expansion of an industry in America which shall place upon our markets a series of American brands of fancy cheese, and which shall open a new outlet for the dairy products of our farms. Up to the present time, these processes, involving as they do bacteriological knowledge and experience, are too difficult to be undertaken by the average farmer. Beyond much doubt they will in the future extend until the American dairy industry has a possibility of utilizing and developing a large market for the delicate, fancy cheeses so common in Europe. This possibility is dependent solely upon the success with which our bacteriologists can devise practical and feasible methods of handling the desired types of organisms.

From this brief summary it will be seen that there is no phase of the dairy industry that has not been modified and revolutionized by bacterial discoveries. The methods of cooling milk for churning and keeping it, the methods of buttermaking, and now the method of cheesemaking, have all been more or less modified, and some of them totally changed within the last twenty years as a result of the rapid expansion of the knowledge associated with milk bacteria. There has rarely been a more rapid and complete change in any industry than that which has occurred in dairying in the last two decades.

THE DRY DISTILLATION OF BEECH WOOD.

THE proverb "all is fish that comes to my net" does not apply in principle (with the necessary alterations) to the charcoal and wood distillate manufacture. There is wood and wood. Hard wood, for instance—and especially beech and poplar—can be considered as composed practically of only cellulose and water; and the distillates may be considered as only products of the disintegration of the cellulose by the heat; whereas pine and similar soft woods contain, in addition to the cellulose and water, great quantities of turpentine, which is a solution of rosin in terpene. Further, there is less cellulose per cubic foot in the soft wood than in the hard.

Steaming soft wood drives out the water, with it the volatile turpentine; and the rosin is melted out. After this has taken place, the process is about the same as with hard wood; namely, the cellulose is disintegrated by dry distillation; except that the rosin that was at first melted out yields rosin oil. It is desirable to recover the turpentine before this period of dry distillation, to prevent any undistilled rosin from going over into the tar. If this be done, there will be some compensation for the lighter yield of charcoal, lime acetate, and wood spirit, as compared with that from hard wood. That is, the object is to get (1) a turpentine free from rosin oil, and (2) a tar free from rosin.

The Usual European Method.—Starting with 100 cubic meters =3,531.5 cubic feet or 27.6 cords of beech wood, weighing 40,000 kg. = 88,000 lb. avoirdupois, there are obtained 115,000 kg. = 25,300 lb. av. of charcoal, 20,599 kg. = 45,300 lb. av. of raw wood vinegar and tar, and 8,000 kg. = 17,600 lb. av. of gas. The tar is let settle from the vinegar, and there are then obtained 18,500 kg. = 40,700 lb. av. of crude wood vinegar and 20,000 kg. = 44,000 lb. av. of crude tar. The crude vinegar is distilled and the vapors passed through milk of lime; the crude tar is freed from water by distillation and yields

(a) 400 kg. = 880 lb. av. of crude wood vinegar (which is sent to that obtained in the first place);

(b) 1,320 kg. = 2,904 lb. av. water-free tar; and

(c) 80 kg. = 176 lb. av. of light oil, which requires refining.

The two batches of crude vinegar yield together

(g) 6 to 10 per cent of retort deposits and 1,800 = 1,980 lb. av. of water-free tar;

(h) 12,000 kg. = 26,400 lb. av. of 20 per cent lime acetate lye;

(i) 5,000 kg. = 11,000 lb. av. of 10 per cent crude wood spirit;

(j) 5,400 kg. = 11,800 lb. av. of steam.

The lime acetate lye is evaporated to 5,000 kg. = 11,000 lb. av., yielding

(k) 7,000 kg. = 15,400 lb. av. steam and

(l) 5,000 kg. = 11,000 lb. av. of 50 per cent lime acetate.

This latter is then dried by combustion gases, and yields

(m) 2,500 kg. = 5,500 lb. av. of steam and

(n) 2,500 kg. of gray acetate of lime.

The 10 per cent crude wood spirit is rectified and yields

(o) 660 kg. = 1,452 lb. av. of 82 per cent raw spirit.

The American Method.—The American process of distilling hard wood differs from the foregoing as follows:

100 cubic meters = 3,531.5 cubic feet or 27.6 cords of air-dried beech wood, weighing 800 kg. = 1,760 lb. av., are distilled, and deliver (as with the ordinary European process) 11,500 kg. = 25,300 lb. av. of charcoal, 21,500 kg. = 47,300 lb. av. of mixed crude wood vinegar and tar, and 8,000 kg. = 17,600 lb. av. of gases. The vinegar and tar are separated by standing, and yield as before 18,500 kg. = 40,700 lb. av. of crude wood vinegar and 2,000 kg. = 4,400 lb. av. of crude tar.

But from this on the process is somewhat different; as from the 4,400 pounds of crude tar are distilled 400 kg. = 880 lb. av. vinegar, 1,520 kg. = 3,344 lb. av. water-free tar, and 80 kg. = 176 lb. av. of light oils. The 1,520 kg. = 3,344 lb. av. of crude vinegar resulting from the distillation of the crude tar is, after being added to the 18,500 kg. = 40,700 lb. av. of vinegar, distilled, in order to free it from tar; the result being

(1) 17,100 kg. distilled wood vinegar.

(2) 1,200 to 1,800 kg. = 2,640 to 3,960 lb. av. of water-free tar.

This latter, being allowed to settle, yields—

(3) 17,100 kg. = 37,620 lb. av. of oil-free distilled wood vinegar and

(4) A quantity of oils.

The wood vinegar is neutralized with 4,000 kg. = 8,800 lb. of milk of lime; the result being—

(5) 21,100 kg. = 46,420 lb. av. of lime acetate lye; which by simple distillation is disintegrated into—

(6) 4,000 kg. = 8,800 lb. av. of 15 per cent wood spirit; and

(7) 17,100 kg. = 37,620 lb. av. of lime acetate lye.

The wood spirit is rectified and produces—

(8) 1,400 kg. = 3,080 lb. av. of 42 volume per cent wood spirit, and

(9) 2,000 kg. = 4,400 lb. av. of water and oils.

The lime acetate lye is filtered and evaporated by steam to—

(10) 12,100 kg. = 26,620 lb. av. of steam and

(11) 5,000 kg. = 11,000 lb. av. of 50 per cent gray lime acetate.

This latter is by means of combustion gases further evaporated, yielding—

(12) 2,500 kg. = 5,500 lb. av. of steam and

(13) 2,500 kg. = 5,500 lb. av. of bone-dry gray lime acetate.

There are required by the old European process 43,040 kg. = 94,688 lb. av. of steam and 9,360 kg. = 20,592 lb. av. of charcoal; by the present American system, 57,240 kg. = 125,928 lb. av. of steam and 11,154 kg. = 24,539 lb. av. of charcoal.

The New European Process.—By the new process, as commenced in Europe, the following shows the course of the materials and the results therefrom:

100 cubic meters = 3,531.5 cubic feet or 27.6 cords of beech wood delivered by dry distillation.

(A) 11,500 kg. = 25,300 lb. av. of charcoal.

(B) 17,100 kg. = 37,620 lb. av. of clear wood vinegar.

(C) 3,320 kg. = 7,304 lb. av. of water-free tar.

(D) 80 kg. = 176 lb. av. of light oils.

(E) 8,000 kg. = 17,600 lb. av. of gases.

The clear wood vinegar is neutralized with milk of lime, then deprived of its spirit by distillation; yielding—

(F) Crude wood spirit of 80 to 90 per cent, and

(G) An alcohol-free solution of acetate of lime.

This latter being evaporated and dried as in the other process, yields gray acetate of lime of 80 to 82 per cent strength.

There are required 12,400 kg. = 27,280 lb. av. of steam and 6,000 kg. = 13,200 lb. av. of coal.

Fuel Consumption.—By this process, instead of there being used 186 kg. = 409 lb. av. of coal (80 kg. = 176 pounds under the retorts and 106 kg. = 233 lb. av. under the boilers) per cubic meter of wood, there are needed only 120 kg. = 264 lb. av.; of which 89 kg. = 196 lb. av. are used under the retorts, and 31 kg. = 68 lb. av. under the boilers; or a saving of coal of 35 per cent.

One of the principal advantages of the new system is the employment of much larger retorts, holding from 10 to 25 cubic meters = 353 to 883 cubic feet, or 2.77 to 6.43 cords, instead of as formerly 1.2 to 1.5 cubic meters = 42.4 to 53.0 cubic feet = 0.331 to 0.414 cord each.

GREEK EYESIGHT.

By DR. CHARLES W. SUPER.

THE Greeks looked upon the external world with emotions very different from the moderns. Let us inquire what means they possessed, if any, for strengthening the sight or aiding defective vision. The problem has been a good deal discussed. Those who believe that some sort of apparatus corresponding to modern eye-glasses has been in use from almost time immemorial rely chiefly upon inference, since hardly any direct evidence is forthcoming. It is held by some investigators that the very large number of seal rings and seal cylinders, both intaglios and cameos, dating from the remotest times found in the Babylonian tombs, must be accepted as proof positive that the art of cutting the hardest precious and other stones was a regular business in that part of the world, and that this could not have been carried on without some kind of magnifying lenses. That work of this sort could be performed only by persons of exceptionally keen eyesight is beyond question: the inference drawn from modern experience is logical. Yet in the absence of objects which might reasonably be expected to be forthcoming, we are constrained to render the verdict "not proven." So far as we have direct testimony, it is all adverse, if the expression be admissible. It is generally held that the first mention of magnifying glasses is found in an Arab writer of the eleventh century. Roger Bacon speaks of glasses that correct refraction. The epitaph of a certain Salvinus Armatus in Florence names him as the inventor of spectacles, although it is also said of the monk Alexander of Spina, that he made use of eyeglasses. In the year 1488 makers of spectacles are mentioned in Nuremberg. There is a passage in Scott's "Quentin Durward" that represents Lord Crawford with spectacles on his nose, and the remark is added that the invention was recent. That artificial aids to sight are modern is also rendered probable from the lack of a word inherited from antiquity to designate the apparatus. The English word "spectacle" is still used in a sense that differs but little from its Latin parent: it is something to look at, a stage-play, then the theater itself. But the earliest English "spectacle" is used for spy-glass. It is thence probable that our plural "spectacles" originally meant a pair of spy-glasses, a sort of anticipated binocular. The French *spectacle* still has its original Latin meaning, the form of the word being but slightly changed. On the other hand, in the German and Scandinavian languages, *Spektakel* is equivalent to what we call a "rumpus." But *Brille* (spectacles) is from beryllus, the Latin name of a transparent stone. The French *besicles* also point to beryl. *Bericle* is an earlier form of *besicle* for "besiculum," a little beryl. In some of the French dialects the first syllable *ber-* is still preserved, but the Parisian word for spectacles is *besicles*, in which the original *r* has been changed to *s*, according to a phonetic law traceable in other words also. The Spaniards, Italians, and Russians have each a native word to designate this article of common use. —Popular Science Monthly.

New and exceptional minerals from Ceylon have recently been exhibited at the Royal Society. These were found during the course of the Mineral Survey of Ceylon now in progress in connection with the Imperial Institute, where the composition of these materials is being investigated. (*a*) Zirkelite. A rare mineral containing the oxides of titanium and zirconium together with variable proportions of other oxides. Three varieties are shown: (1) containing 20 per cent of thoria and 1 per cent of uranium oxide; (2) containing 8 per cent of thoria and from 2 to 5 per cent of uranium oxide; (3) containing traces of thoria and 15 per cent of uranium oxide. The crystals, which belong to the hexagonal system, differ also in specific gravity. An account of these varieties of zirkelite will shortly be communicated to the Royal Society. In exhibiting variation in the proportions of thorium and uranium the zirkelite of Ceylon shows the same peculiarities as thorianite. (*b*) Baddeleyite. Notable as a definitely crystalline form of this mineral. Some crystals exhibit twinning, others are untwinned. The mineral is essentially oxide of zirconium. (*c*) Thorite. Notable as an anhydrous form of the mineral with the high specific gravity of 6. Essentially a silicate of thoria, containing 74 per cent of thoria. (*d*) Monazite. Consists mainly of phosphates of the cerium metals, notable in containing variable and unusually high percentages of thoria. The three specimens shown contain 10, 15, and 28 per cent of thoria respectively.

A RAILROAD UNIVERSITY. ALTOONA AND ITS METHODS.

(*Continued from first page.*)

the following extensions were made in the main during 1902 and 1903: The original structure of the machine shop was 75 by 258 feet, two stories high; erecting shop 70 by 354; blacksmith shop 80 by 306; boiler shop 80 by 386. This shop was extended in length to 722 feet and the runway of its crane was extended 160 feet beyond the end of the shop for the purpose of handling supplies stored in the yard. The blacksmith shop grew to a length of 514 feet and an additional blacksmith shop 80 by 210½ feet has been built. The machine shop has been more than doubled in length, being now 578 feet 6 inches. The erecting shop is now 579 feet 9 inches in length. The boiler house, originally 45 by 70, was enlarged to 45 by 151 feet. The original office building provided space for the care of stores, but in order to provide additional space for both of these departments a new storehouse was erected, 45 by 151 feet 1¼ inches in dimensions. The traveling-crane runways of the machine shop were extended to 60 feet beyond the west end of the shop.

Raw material comes in at one end of the boiler shop and as it passes along through the building is sheared, flanged, punched, assembled, and riveted and finally passes out at the opposite end without having gone over the same path twice.

machine shop, but this does not affect the general plan of things.

Locomotives to the number of 275 comprise the annual capacity of the Juniata shop. At the present time about 1,642 men are employed, exclusive of the heads of departments, together with the clerks and all others employed by the month, and are distributed as follows: boiler shop, 490; machine shops, 511; blacksmith shop, 298; erecting shop, 201; yard, 48; carpenter shop, 30; boiler plant and engine room, 33; paint shop, 24; scale department, 12.

While no further extensions are under way at the present time, the lay-out of the shops is such as to enable the main shop buildings to be duplicated, thereby affording possibility of an output of 500 to 600 locomotives a year.

From all over the Pennsylvania system east of Pittsburg cars and locomotives by the thousand are sent to the machine shops to be repaired, and in consequence the total floor area of nearly 80 acres in the shops is none too large, even without the heavy rushes that frequently occur.

To take advantage of these extraordinary facilities students gather and learn railroading from the bottom up. "Silk stockings" find no places for them; there is the ultimatum of work or departure. And it is dirty, grimy work that severely tests the measure of young men. However, a graduate is splendidly equipped as a result of his apprenticeship.

The young men who come to take a course in the

No textbook is used, nor is any special reading required in the special apprentice system, which has been in operation since 1871. The superintendent of motive power is in charge of the course.

Any man available to rise to the highest position usually goes through the grades of inspector, assistant master mechanic, assistant engineer of motive power, assistant road foreman of engines, road foreman of engines, master mechanic and superintendent of motive power. Naturally enough the line of promotion is not fixed by any rigid rule.

Many bright young men of good parentage, having passed through college and being vouched for by one of the general officers of the company, put on jumpers and spend several years in the shops in order to fit themselves for higher work in the railroad service. And that they may attain their ambition is shown by the case of Frank Thomson, a former president of the system, who was a graduate of this manual-training school. It was in the Pennsylvania Railroad shops that he became thoroughly conversant with railroad construction.

Students of railroading at Altoona learn that to take care of the steady flow of traffic, increasing day after day, week after week, a remarkable machinery of yard management and train manipulation has of necessity been developed. The intricacy of it causes dizziness in the head.

Smoke-hung, dirty freight trains in excess of fifty steam daily into the yards, shunt their cars along the

FIRST FLOOR OF THE JUNIATA MACHINE SHOPS.

The lower view shows the west end; the upper, the east.

THE SECOND STORY OF THE MACHINE SHOP.

The east end above; the west below.

A RAILROAD UNIVERSITY.

The whole operation is similar to the passing of an earnest student from class to class, each year adding to his store of knowledge till at last he emerges from the shops of learning a completed product.

Upon completion the boiler goes into the erecting shop, the end of which is directly opposite that of the boiler shop. The blacksmith shop is beside the latter. From the former the frames and forgings enter the machine shop, which occupies the same relative position to it as the erecting shop does to the boiler shop. The lay-out of the machine shop is such that the forgings are finished as they pass through without going over the same path twice, and they reach a completed stage at about the center of the building. The cylinders and other castings enter the machine shop from the opposite end, and after going through the various machining operations they reach a completed stage where they meet the frames and other forgings.

From this point the parts go in company through a side door to the erecting shop, and are there met by the boiler which has come in from the boiler shop. In one section of this shop the wheel centers are turned and bored, the axles and crank pins are turned, the tires are shrunk on, and the wheels completely assembled. Lighter machine work, such as making bolts, pins, staybolts, main and parallel rods, valve-motion work and the like, is done on the second floor of the

shops are called special apprentices, and they are put to work in the blacksmith, tool, wheel, tank, and boiler departments; then they learn how to keep accounts in the shop-clerk's office. Still more time is spent in the drawing room under the supervision of Axel S. Vogt, the mechanical engineer of the road, or in the laboratory. Throughout the course the apprentices are carefully watched and directed. A record of every man's performance is kept. The only educational requirement for admission to the course is that the applicant be a graduate of a technical school or college. There are four years in the course, divided as follows:

Erecting shops	6 months
Vise shop	3 months
Blacksmith shop	2 months
Boiler shop	2 months
Roundhouse	4 months
Shop-clerk's office	2 months
Test department	5 months
Machine shop	6 months
Air-brake shop	2 months
Iron foundry	2 months
Car shop	6 months
Firing on road	3 months
M. P.'s office	2 months
Drawing room	3 months

tracks, where new trains are made up by a force of twenty-five yardmasters and assistant yardmasters who have charge of the work. Under them are hundreds of clerks, car makers, lever men, switchtenders, enginemen, conductors, and brakemen.

In the department of the principal assistant engineer are gathered from all points on the lines East—this meaning Pittsburg—young civil engineers eligible for promotion to the position of assistant supervisor. These youths, after completing their education at technical schools and colleges, have entered the service of the company either in the construction department or in the offices of division superintendents. As they show fitness they are sent to Altoona, where a record is kept of their age, education, and previous experience. They become acquainted with the general routine of the maintenance-of-way work and with the Pennsylvania methods of operating a railroad. From this force men are appointed assistant supervisors. Then in order of seniority they become supervisors, assistant engineers, superintendents.

There is nothing for which the increasing prosperity of the United States has created a greater demand than trained railroad men. As there is no railroad school or college in the United States, Altoona is the best substitute for such institutions and it has grown to vast proportions and become, in reality, the *alma mater*

of railroad men. No like parallel is presented by any other city. Altoona is the last word in practical railroad education. After completing the course two things are still to be gained, things that come gradually to men in the making—executive experience and equilibrium.

In Altoona are gathered a number of the principal operating officials of the road and with them their families. At best the city is not a garden spot, and a pressing problem proved to be the arrangement of social facilities for the railroad employees. Therefore, just as they would set about the building of a new roundhouse or car shop, in the same businesslike manner, the railroad officers attended to making conditions as agreeable as possible for the men. The Altoona cricket club, which had been in existence for many years, was converted into a club for the officers of the maintenance-of-way, motive-power, and other departments, and the special apprentices. The club is located on a high hill which rises far above the valley in which run the railroad tracks. Golf links, tennis courts, indoor games, and all of the appointments of a well-regulated club are provided. For the men employed by the railroad company the Y. M. C. A. has club facilities, and nowhere has such a branch of this organization been more thoroughly developed.

During the latter days of February the city of Altoona added to its educational facilities a railroad high school, which is the first institution of its kind in the United States. Its progress may mark the beginning of a new era in education, if other industrial corporations see the advantages of forming such a working partnership with the public schools as the Pennsylvania Railroad has made in Altoona. The industrial department of this high school is fully equipped and all bills are paid by the railroad company. The department has nothing in common with manual training. A four years' course is planned, beginning with mechanical drawing and ending with machine design. The creation of the department is the result of a desire on the part of the railroad to discover a way to combine its needs for trained employees with the aim of the public-school authorities to turn out young men ready to earn a living.

A drawing room, carpentry shop, forging room, a wood and metal-working machinery department—all equipped with modern tools—together with the expert instruction to be provided, will enable the school to give students advantages heretofore enjoyed only by pupils of the best technical schools.

Graduates of the Altoona high school will be fitted to go directly into the Pennsylvania shops on a footing between the regular apprentices, who as a rule entirely lack training, and the special apprentices who are graduates of technical schools. The railroad's return on its investment is expected in the form of better educated employees.

The Pennsylvania does not alone bear the indebtedness to Altoona for thousands of its principal men, for many other railroads have drawn operating officials from among those who have learned the art of transportation here. When the International Railway Congress met in the United States two years ago one of its chief purposes was to visit the "greatest railroad town on earth."

BLACKSMITH SHOP, WEST END; JUNIATA SHOPS.

THE AMATEUR'S FOUNDRY.*

By WALTER J. MAY.

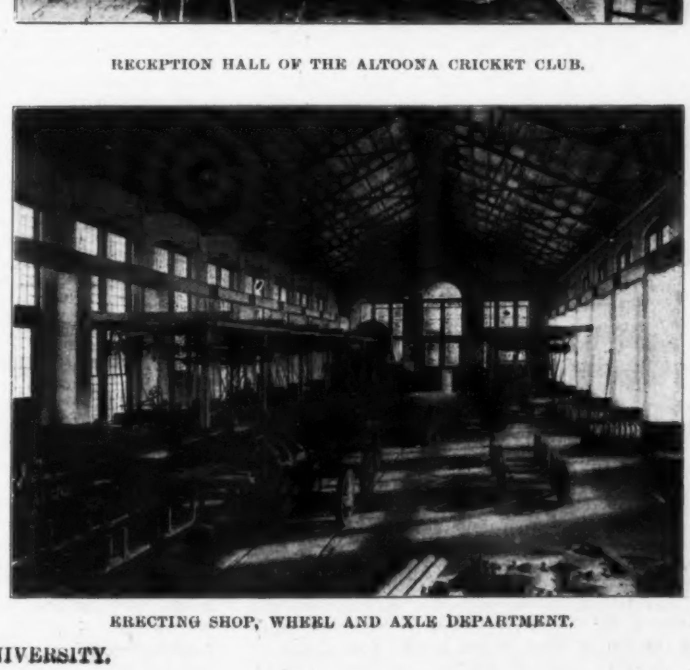
SMALL or comparatively small things only should be dealt with, and probably nothing heavier than about 25 pounds in the actual casting should be attempted. This really means that one has to deal with a weight of from 30 pounds to 35 pounds of metal, a crucible weighing from 7 pounds to 10 pounds —the writer has never weighed plumbago crucibles of small size—and a pair of tongs weighing from 8 pounds to 15 pounds, according to make, which means that from 45 pounds to 60 pounds has to be hauled about, and amateurs will find this a fair task, especially when it is considered that both the metal and crucible will often be blazing hot. Of course some of the metals and alloys fuse at a low temperature, and these do not require even a red heat; but when brass or iron is being dealt with, somewhat intense heat has to be used to get the metals fluid enough for pouring.

This leads up to the consideration of the melting furnace, and for general work the top of this should be level with the floor, as this is not only safest, but it is most convenient, as it is easier to lift from beneath you than to lift from a raised position. Probably a Carr's furnace of a size commensurate with that of the largest crucibles to be dealt with would give the best results; but a built furnace could be used if so desired. The erection of these has been more than once described in these pages, and need not be fully detailed here, as space is rather too valuable to be used for needless repetitions. Where only small weights of metal are required, one of the small portable furnaces sold by the Morgan Crucible Company, and also by some other firms, will usually be sufficient; but all depends on the actual requirements of the user. In any case, however, the furnace must be large enough to hold sufficient fuel to melt properly, and the draft—of course, natural-draft furnaces will be always used—must be strong enough to secure the proper combustion of the fuel. It is always possible to reduce the draft by means of dampers in the chimneys; but the mere presence or otherwise of a damper

* English Mechanic.

RECEPTION HALL OF THE ALTOONA CRICKET CLUB.

IN THE BOILER SHOP.



ERECTING SHOP, WHEEL AND AXLE DEPARTMENT.

A RAILROAD UNIVERSITY.

will not increase draft where it does not exist. As a general rule, furnace chimneys have to be from 15 feet to 25 feet high, and of sufficient area; but local conditions generally cause a lot of variations, scarcely any two melting furnaces being alike in regard to the chimney arrangements.

A pair of crucible tongs for each size of crucible used, and a couple of pairs of bowed coke tongs, are necessary for the working of the furnace, while one or two pieces of ¾-inch round bar-iron for poking and stirring purposes will be necessary. A shovel and sieve for the fuel will be necessary, and this completes the special tools for furnace work; but barrows, shovels, and other general tools are from time to time called into temporary use for removing ashes and other odd jobs.

The fuel used should be good hard furnace coke for all but soft metals, where gas-coke can be used; but even with these the presence of an excessive amount of sulphur is not at all times desirable, and to be as free as possible from this objectionable element foundry coke must be used. Initially gas-coke is cheapest, but for aluminium and all metals and alloys needing the same or a greater fusing temperature, it is quite as cheap to use the more expensive hard coke, as a smaller consumption takes place. Iron *must* have hard coke as fuel, and the same may be said of copper, but brass can be melted with decently hard samples of gas coke. Coke should be broken so that the largest pieces should be about the size of eggs, and all passing a ¾-inch square mesh sieve should be thrown out as useless, as this small stuff only chokes the fires, and for this reason makes the process of melting a troublesome one. A shed should be provided in which to keep the stock of coke, as it is a messy thing to have in the workshop; but, at the same time, it must be borne in mind that the weather does not affect this fuel. The small rejected coke can be passed through a ¼-inch square mesh sieve, and that held in the sieve is very useful for the forge, as it gives an intense heat and keeps up a very clean fire, the only disadvantage being that it does not run together like coal, a point which is often disconcerting to the amateur blacksmith.

Bins for sand must be provided, these being under cover to keep off rain. Two or three of these, holding just over a cubic yard each, will be all that are necessary, the sand for some purposes being continually used over again, while for some other purposes new sand must be used for facing each time, and as it is quite out of the question to think that an amateur will go in for floor work, the necessity for bins becomes apparent.

Bins or boxes of moderate size will also be needed for ground coal and charcoal, but these need not be of large size, as bags of about a hundredweight each can be had from time to time as needed. Plumbago, ground steatite, parting sand, and other stores can be kept in boxes of a size suited to the amount of each material stocked; but the bulks will not be large necessarily, and so long as the store is kept dry there need be no waste.

Crucibles should be as nearly as possible of one size for general work; but as it is a waste of both fuel and crucibles to melt a few pounds of metal in a large pot, at least two sizes should be kept—say, for instance, 40 pounds. "Salamander" pots are used for the general meltings; there should be a few 20-pound pots kept in stock, and if we start with a half a dozen of each, this should be ample. Crucibles must be kept in a warm, dry place, and before firing should be stood at the back of the furnace for a few hours to insure thorough dryness. Plumbago crucibles should always be used, as they stand cooling-off without fear of splitting, whereas clay pots will not stand cooling. A few iron metal pots for lead and tin may also be had, say, about three of various capacities, but in regard to this the amateur founder must be the judge; but in any case an iron metal-pot to hold 10 pounds to 15 pounds of lead, with its accompanying hand ladle, should always be about the place, as it often comes in very handy for odd jobs which may be expected to crop up at unexpected times.

Coming to the fittings needed, a stout bench for molding on is necessary, as this saves a lot of backache; and, besides this, it prevents the amateur going on his knees to work, as is done by the general iron-molder. As a rule, the amateur can work better on a bench, and for light work there is no real reason why it should not be bench-work. Firmness and stability are desirable for a molding bench, and it should be of a height suited to the worker; while a shelf should be about a foot above the bench, on which to place tools and other impedimenta used in molding. It is really wonderful what a knack of getting lost in the sand tools possess, and often in a foundry it is only when sand is sifted that lost sleekers, heart-trowels, and the like come to light, and some of these things are of quite a respectable size and weight. An arrangement can be made to keep the working stock of backing sand under the molding bench—a point which both economizes space and proves convenient where room is limited; but this is a detail for the decision of the individual rather than a matter of any general importance.

Flasks or boxes for amateur use should not be too heavy, and in many cases may be made of fairly stout sheet or plate iron, according to their size; but more usually they are cast. Provided they are well made and accurately fitted, the method of manufacture matters but little; but where large castings are made, weight has to be more or less a matter for consideration. In every case, and whether the boxes be stayed or not, the sides must not "spring," or the sand will drop out and the molds be spoiled. Generally speaking, the simpler the box is in design, the better it is for the molder, although amateurs usually want to do intricate work before they are able to do the simpler forms of casting. In a trade foundry you have boxes which are very suitable for the run of work done as a rule; but when it happens that some more or less awkward thing has to be cast, the molders have to make the boxes fit the work in hand; and, truth to tell, the expert jobbing molder is rarely at a loss, although at times his molds have a very fearsome arrangement of wood and iron to make them hold together; but so long as he gets out his casting all right this troubles him but little. Two and three-part boxes will be necessary, and really it is well to have boxes with interchangeable parts so as to reduce the number as much as possible. If the amateur has boxes ranging from 10 inches square to about 12 inches by 18 inches square, with drags 6 inches deep and copes 4 inches deep, with some 2-inch and 3-inch center parts, he will have all he can manage, while, probably, the 10-inch square boxes will take the bulk of what he has to do. As a matter of fact, however, the boxes should be selected to fit the run of the work proposed to be dealt with, and in regard to this each person will have his own individual requirements. It is not advisable for amateurs to deal with other than rectangular boxes, or otherwise he will find trouble. Boxes of almost any size are purchasable from the many dealers in foundry supplies, and they are not specially costly. Of course, when once the amateur has his foundry running, he can cast any boxes he may require if he likes to do a bit of floor molding; but, really, with a half-dozen three-part boxes in three sizes, no further stock should be needed by an amateur doing model and other small work.

In regard to patterns, probably these will be made by the amateur himself, or he will have them made by professional patternmakers, the last plan being the most satisfactory as a general rule, provided the persons having the patterns made can make scale drawings with a fair degree of accuracy. Of course, either the draftsman or the patternmaker will provide for the necessary allowance for contraction of the metal and for machining purposes; but each party should not make these allowances, or the result will not be at all good. Where only an occasional casting is required from a pattern it may well be made of soft pine, as may, also, the core boxes; but when they are to have a lot of use, they should be made in mahogany or metal patterns, and core boxes should be prepared from those made of soft pine. This, of course, is a detail which is only determinable by the person having the patterns made; but it is one well worth attention.

All patterns for amateur use should be made to favor the molder as far as possible, and split patterns should be largely used, as these usually tend to increase the facility of hand molding where the pattern is partly in each part of the box. Rapping and lifting plates should be used wherever necessary, although the professional molder does not at all times care for these things. Careful doweling is necessary where the patterns are split, as they should be an accurate fit when the parts are assembled together; but, no doubt, this is a rather unnecessary point to mention, as it will appeal to any one having to do with molders' patterns.

In regard to tools, an ordinary and a heart trowel, two or three cleaners, some sleeking tools (most of which may be home-made), two or three brushes, and one or two pots or small buckets for water and clay and black-washes, with a peigning and flat rammers, will be all that is absolutely needed, plus one or two venting wires; but the amateur will find scope for his inventiveness in designing special tools for particular jobs, and it does not follow that because only a few tools are absolutely necessary, others should not be made and used. For instance, on one occasion the writer had a large number of brasses to turn out, these being of set sizes and similar design. A set of sleeking tools were made specially for the job, which effected an economy of five per cent in labor, paying handsomely for their cost; and as they were in frequent use afterward, the mere making became a very small matter. It is a point always to be borne in mind, however, that it is skill and practice which make the molder, and not merely the tools he possesses, and without practical skill the molder is nowhere. You *must* practically learn molding, and no amount of college or technical school teaching will alone enable you to work expertly, and it is just in this particular point that so many fail. If you are working practically at any trade, and at the same time you take technical school lessons, you will find it to your advantage; but the technical school lessons alone are practically a loss of time, money, and energy—particularly in regard to molding.

As to learning molding, the best method for the amateur to adopt is to get hold of some practical molder, and get him to practically show and explain the methods of working, and men willing and able to do this during their spare time in the evening are not difficult to find. With a little care it is quite an easy matter to get hold of the essential points of molding plain work, if you do not mind soiling your hands, and in a short time, under the guidance of an intelligent molder, it should be possible for the amateur to do very decent work, as time and labor costs do not count, as under a commercial rule they are obliged to. There is one very certain thing: you cannot learn molding and casting from books alone, and no man can write a book which can teach you without practical teaching; but after you know something of the work practically, then books are of almost inestimable value if you can apply their teaching to the subject you have in hand. Besides special books, there is also much information to be gained from queries answered by our own and other mechanical papers, provided they be asked in an intelligent manner: and the writer and a good many others always have pleasure in replying to intelligent, clearly-put questions. There is no need, therefore, to lack information, and, provided the information is followed up practically, there will be no reason to fear failure. Do not, however, start with metal or plaster molds until you understand sand molding pretty well; if you do, you will not have any great success to register.

EXPERIMENTAL RESEARCHES ON THE ORIGIN OF SPECIES IN THE VEGETABLE KINGDOM.

By F. PÉCHOUTRE.

ALTHOUGH the theory of descent founded by Lamarck and Darwin is now almost universally accepted this is not the case with the hypothesis concerning the method of descent, or the mechanism of the formation of species. The two questions, in fact, are quite distinct. The theory of descent is susceptible of proof which has been abundantly furnished by comparative anatomy, embryology and paleontology, while the formation of a new species is a physiological phenomenon which can not be thoroughly understood until it has been brought within the domain of experiment.

It is quite evident that experimental methods can not produce the great branches of the genealogical tree: classes, orders, families, genera or even good species, the development of which is lost in the darkness of time and has never been observed by man. But the smaller branches and twigs: poor species, varieties, strains and still smaller connected groups, may be more amenable to experiment, and it is not improbable that some of these ultimate subdivisions may be even now in process of formation. If this is true, the formation of slightly differential species becomes a concrete problem, the solution of which is necessary and sufficient to substitute fact for speculation and explain by analogy the formation of the grand systematic groups, for there is no essential difference between larger and smaller divisions. It must not be forgotten, however, that the great branches, being the result of long continued evolution, may have been subjected to influences which no longer exist or which operate so slowly that their effects can not be detected within the time limit of experiment.

Darwin, particularly impressed by the results of artificial selection, which enables man to promote the development of useful or desirable variations, ascribed to natural selection the principal rôle in the formation of species. Just as the horticulturist or the breeder of animals preserves only the varieties that appear to him the best, so natural selection assures the survival of the fittest by means of the struggle for existence. Plausible though this hypothesis may appear it has not been accepted by all biologists. One of its most severe critics is Hugo de Vries, who in his "Theory of Mutation" (1901-1903) assails with vigorous logic the foundations of the theory of selection and strongly opposes those evolutionists who regard selection as a creative agency.

Variation, without which the formation of species is incomprehensible, includes at least two forms, which Darwin formally distinguished. One form, individual variation, is very common; the other, spontaneous variation, is very rare. Which of these variations is affected by selection? In his early works Darwin gave the preference to spontaneous variation but later, influenced by his associates, he appears to have inclined toward individual variation. Nowhere, however, does he express a definite and final opinion. Wallace, the co-founder of Darwinism, was the first to assert that species are produced by selection among individual variations. In his view, animals and plants vary continually under the conditions requisite for the formation of new specific types. The spontaneous variations have no effect on posterity and only individual variations, slowly effected and intensified by selection, are of importance.

These conclusions are not in accordance with the subsequent progress of our knowledge of individual variations. These variations obey Quetelet's law which, in connection with the work of Galton, Weldon, Bateson, Duncker, and others, has opened a new phase of biological research: the statistical study of variation and heredity. The results of these researches show that individual variations, whether they are common, fluctuating, gradual or continuous, group themselves about a mean value, on each side of which the frequency of a given variation is inversely proportional to its magnitude. The curve of variation obtained from a great number of observations is identical with the curve of probable error.

For example, common beans vary in length from 8 to 16 millimeters. Among 448 beans, taken at random, the following numbers of beans of various lengths were found:

Length in millimeters.	Number of beans.	Length in millimeters.	Number of beans.
8	1	13	106
9	2	14	33
10	23	15	7
11	108	16	1
12	167		

If these lengths are laid off as abscissas, and at the extremity of each is erected an ordinate of height

proportional to the number of beans of the length denoted by the abscissa the line drawn through the extremities of the ordinates is found to be a symmetrical curve similar to the curve which represents the development of a binomial.

What effect does artificial selection have upon individual variations and what is the result of the application of the statistical method to them? If we select for reproduction individuals with extreme characters (very long or very short beans in the example chosen) we usually obtain a variegated progeny with characters represented by a curve similar to that of the preceding generation. But the two curves are not identical. The highest point of the curve of the second generation, corresponding to the mean length, is displaced in the direction of the length of the actual parents, which it nearly attains. If the extreme individuals on the same side of the curve are again selected for reproduction the apex of the curve, representing the mean length of the third generation, is displaced again in the same direction but still it does not quite reach the point corresponding to the length of the parents and the displacement is smaller than in the former case. By continuing this process additional displacements are produced but each displacement is smaller than the preceding so that finally the result of selection becomes practically *nil*.

Maize furnishes a good illustration of this law. In an ear of maize the kernels are arranged in longitudinal rows of varying number. In a given breed or strain the number may fluctuate, for example, between 8 and 20. The commonest number will be 12, the next in frequency 14. Ears with 10 or 16 rows will be few, and ears with 8 or 20 rows very rare. If the kernels of an ear of 16 rows—more than the average number—are sown, the plants which they produce will bear ears containing from 8 to 22 rows, 14 and 16 being the commonest numbers, 12 and 18 rare, 10 and 20 very rare, and 8 and 22 exceptional. If the process of selection is continued by taking a 20-rowed ear for seed, the commonest numbers of rows in the progeny will be 16 and 18. A slight gain may be obtained by continuing the selection through several generations, always taking for seed an ear with more than the average number of rows, but it is not possible to produce a crop averaging more than 18 rows to the ear.

Analogous results are obtained by operating with ears having fewer than the mean number of rows.

If the process of selection is discontinued the mean number of rows gradually returns to its original value so that the gain acquired is lost and even if selection is continued no further progress is made.

Natural selection might appear to be able to produce a permanent result, in consequence of its long continuance, but as it acts under conditions less favorable than those which attend artificial selection and as, on the other hand, experiment has proved that the whole of the possible improvement is obtained very quickly, it is fair to infer that natural selection can have no greater effect than artificial selection. The hypothesis that the long continuance of natural selection can make the variations permanent and hereditary eludes all attempts at confirmation.

Hence it is impossible to prove that natural selection applied to individual variations has ever developed new characters and made them hereditary.

Another criticism of Darwin's theory has been made by Bateson, who maintains that the theory of selection, if true, should explain discontinuity as well as affinity of organic forms. The species now in existence are sharply separated from each other. This grave objection to the theory of progressive and continuous variation is not removed by the discovery of numerous intermediate forms, for many of these appear as clearly defined and permanent groups without gradation toward either specific type. The theory of selection also fails to account for the numerous useless modifications which appear as specific characters. As Bateson remarks: "The fact of variation simply suggests that the discontinuity of species results from discontinuity in variation."

In spontaneous variation the alterations are not gradual or continuous but sudden and immediate. To this category belongs the case in which some buds produce branches unlike the other branches of the same plant. Another example is given by Darwin's "single variations." These are solitary individuals very different from their parents, appearing very rarely and becoming the progenitors of new and constant varieties. Are we to believe the assertion of the partisans of selection, that spontaneous variations differ from individual variations only in degree and that the theory of mutation ignores small variations and recognizes only great ones?

No, for the difference between individual and spontaneous variation is qualitative as well as quantitative, and spontaneous modifications are often smaller than individual modifications. The numerous subspecies of *Draba verna* differ less from each other than individuals of a single species. The essential characteristic of spontaneous variation is that it produces at once the entire possible alteration, which is thenceforth hereditary. Selection is useless. The new form remains fixed, even when isolated. Individual variation is hereditary only to a definite and limited degree, but "single variation" is completely and immediately hereditary.

The Russian botanist Korschinsky has collected the facts relating to the appearances of new forms, with a full understanding of their importance in connection with the origin of species, and has given to spontaneous variation the name heterogenesis, which had already been employed by Koelliker. During the 19th century, for example, the locust tree (*Robinia pseudacacia*) produced a number of spontaneous varieties: one without thorns (*mesmis*) in 1833, one with rose-colored flowers (*Decaisnea*) in 1862, one with precocious and profuse inflorescence (*semper florens*) in 1862, and one with simple leaves (*monophylla*) in 1855. All of these forms appeared as isolated individuals among hundreds of normal young plants.

Chelidonium laciniatum, distinguished by its more deeply incised leaves and petals from *Chelidonium majus*, was discovered in 1590 in a bed of *C. majus*, the common celandine, of the poppy family, in a garden in Heidelberg. The new form, which has never been found growing wild, has perpetuated itself without showing any tendency to revert to the parental type. A laciniated variety of alder originated as suddenly by spontaneous variation. In 1900 Solms-Laubach described a beautiful case of spontaneous variation in the shepherd's purse (*Capsella bursa-pastoris*) of which a single plant with ovoid instead of the usual triangular pods was discovered in 1897, at Landau.

Korschinsky failed to recognize the hereditary constancy of these spontaneous varieties, probably because he did not make sure that the seeds produced by the new form were the result of self-fertilization.

Hugo de Vries has attacked the problem by a perfect method and with a success that has withstood all criticism. He has given the name mutation, already employed by the geologist Scott, to spontaneous variation, that is, to Darwin's "single variation," Korschinsky's heterogenesis, or the variation by bounds of some writers. Convinced that individual variation is limited, that the whole benefit of selection may be obtained in a few generations and can be preserved only by continued culture and selection without which it is lost as rapidly as it was acquired, and, finally, that selection applied to individual variation has never produced a new specific character, De Vries regards mutation as the essential factor in the origin of species. In other words, new species are formed by mutation, or the sudden appearance of a new character which is fixed from the beginning.

These revolutionary ideas could not be accepted without long continued and vigorous testing. De Vries has systematically abstained from speculation and relied wholly upon experiment. His culminating triumph is the experimental production of varieties by mutation.

After long search, he found a favorable subject for experiment in a South American species of evening primrose, *Oenothera Lamarckiana*, which in Europe is cultivated as an ornamental plant and occasionally found growing wild. The plant is usually biennial, consisting, during the first season, of a whorl of leaves surrounding the base of a short stalk. In the second year the stalk grows to a height of three or four feet and bears a long spike of large, pale yellow flowers which open in the evening. The plant dies after the seeds have ripened.

In 1886 De Vries found growing wild near Amsterdam, surrounded by normal plants of *Oenothera Lamarckiana*, two clearly differentiated forms which he named *O. levigata* and *O. brevistylis*. The latter, being sterile, could not be used in the experiments but many sowings of *O. Lamarckiana* and *O. levigata* were made. Of more than 50,000 plants thus obtained in seven years, 800 were affected by mutations. They constituted a series of new forms distinguished from the mass of the plants of *O. Lamarckiana* by one or more characters. They were also subject to individual variations. Their characters were found to be entirely constant and hereditary from the beginning, if self-fertilization was assured.

Thus within a few years a species produced a number of "mutants," different from each other and from the original type, whether this were represented by *O. Lamarckiana* or *O. levigata*.

These mutants are not comparable to true or Linnæan species. De Vries calls them elementary species. They differ from each other by a single strongly marked character or by several inconspicuous characters, not by a number of strongly marked characters as is the case with true species. So, as the French botanist Jordan had previously shown, a species is nothing but an assemblage of nearly related forms.

Selection has more power over mutations than over individual variations because mutations are hereditary *ab initio* and also because they usually offer greater differences for selection to work with.

The objection has been made that mutation is too rare a phenomenon to serve as the source of new species. In the experiments of De Vries the average proportion of mutations was between 1 and 2 per cent, and often only a single mutant was found among thousands of plants. But according to Delboeuf's law this rarity does not prevent the ultimate triumph of the new form over the old because the new form is hereditary and consequently is no longer at a disadvantage in the struggle for existence. Hybridization alone can lessen the chance of survival of mutants. If a given territory can support 10,000 plants of an annual species which annually produce 1 per cent of mutants, then, if the primitive species and the mutant have equal chances in the struggle for existence, 9,044 plants of the primitive type will remain after 10 years, 5,000 after 69 years, 3,600 after 100 years, and 68 after 500 years. After 900 years there will be only one plant of the old type among 9,999 of the new. The process will be accelerated if the new variety is favored in the struggle for existence but it will be retarded if hybridization occurs, which is usually the case.

According to the experiments of De Vries, therefore, selection has no power over individual variations except in an isolated species, reduced by mutation to the condition of an elementary species. But the researches of the Danish botanist Johannsen will, if confirmed, remove the little importance in regard to the origin of species that is left to individual variations.

Johannsen experimented with self-fertilizing plants, especially beans. In a great number of plants of the same species growing together, a field crop, for example, or what Johannsen calls a "population," individual variations are found distributed according to Quetelet's law on both sides of the average and most frequent type. Thus in a crop of brown beans the weight of a single bean varies from 200 to 800 milligrammes, and the commonest weight is 500 milligrammes.

If the largest and smallest beans and those of average size are planted separately the progeny of the very large beans will have a greater, and that of the very small beans a smaller average weight than the average weight of the progeny of the medium beans. But if any one of these three groups of "daughters" is similarly subdivided, according to weight, and planted, the average weight of *each* of the sub-groups of "granddaughters" will be sensibly equal to the average weight of the *whole* group of "daughters" to which its parents belonged. In other words, all the improvement that can be obtained by selection is effected by the first selection, and the second selection produces no appreciable gain.

This result is not in accordance with the usual results of selection applied to individual variations and it can be explained only by self-fertilization. Johannsen regards a "population" as composed of constant elements, of even lower order than the elementary species of De Vries, which he calls "lines." Externally, these lines can not be distinguished from each other because the sum of the individual variations within each line is greater than the difference between two lines.

Let us suppose, for example, that a "population" of brown beans is composed of 11 lines and that the mean weight of the beans of the successive lines rises by increments of 20 milligrammes from 400 milligrammes, for the first line, to 600 milligrammes, for the last. If the individual variations within each line do not exceed 5 milligrammes the 11 lines can be separated by weighing the individual beans but the lines cannot be separated in this way if the individual variations within the line exceed 10 milligrammes. As a matter of fact they may exceed 250 milligrammes so that the lines overlap and are inextricably mingled.

In the experiment already cited, the first selection had no effect on the individual variations but simply separated the large, medium, and small lines which already existed as ingredients of a purely mechanical mixture.

When cross-fertilization occurs the lines cross and the individuals become blended physiologically as well as mechanically. By the laws of hybridation the progeny contains some individuals of pure breed. In successive generations the number of these can be increased by selection, but when selection ceases to act these pure strains become merged in the mass by cross fertilization. After a line has become isolated and pure, selection may have no further effect. This is the explanation of the progressive decrease of the improvement effected by selection. Knowledge of the laws of hybridation enables us to understand the process, but not to shorten it, for the characters of the various lines are masked by the individual variations. It is possible, however, that selection may produce some permanent result, on condition that it is applied to a completely isolated line.

Thus, as De Vries has been induced to regard the species as an assemblage of elementary species, Johannsen has been led to dissociate the elementary species into a congeries of constant hereditary lines.

Johannsen's researches also give a plausible explanation of individual variations. These are known to be due, in part at least, to food supply, temperature, and other external conditions. Now as the variations are inherited to a certain degree external influences may suffice to account for them entirely. Part of the inheritance is directly from the mother, the remainder is doubtless due to strains masked by hybridation and subsequently unmasked by external influences. As these influences are grouped about mean values the like arrangement of the individual variations becomes clearly intelligible.

Thus, according to these recent researches, selection permits us, on one hand, to obtain permanent forms as mutations occurring in isolated individuals, and, on the other hand, to separate pre-existent hereditary races from a medley, but it creates nothing new.

Hybridation, likewise, does not produce new characters, but only new and permanent combinations of characters already in existence.

Can any other origin be assigned to species and can the Lamarckian principles, adaptation to environment, effects of use and disuse, be regarded as factors of the genesis of new forms? Their influence cannot be denied; the only question is whether the reactions of organisms to external stimuli result in anything different from individual variations, in the sense in which we have used that term. Lamarck and his school assert that external influences acting on the organism during its development affect the germ plasma in which they produce adaptive changes. Weissman opposes this view. The question is still undecided, and discussions of the transmissibility of

acquired characters do not come within the scope of this article.

To resume, individual variations, as defined by Galton's curves, are only slightly (De Vries) or not at all (Johannsen) hereditary, but mutations are transmitted to offspring entirely and at once. Selection is useful only when it is applied to mutations. Applied to individual variations it merely eliminates without creating anything new. Although mutation is of very rare occurrence it is the only experimentally demonstrated process of the formation of species. We see, also, that the smallest or unit group of the system is not the species, the elementary species or the individual, but the line, that is to say, a determinate portion of germ plasma which assumes the same livery in a greater or smaller number of individuals, so long as the germ plasma is not altered by mutation or perhaps by adaptation. External influences modify only the livery and determine individual variations.—Abstracted for the SCIENTIFIC AMERICAN SUPPLEMENT from La Revue Générale des Sciences Pures et Appliqués.

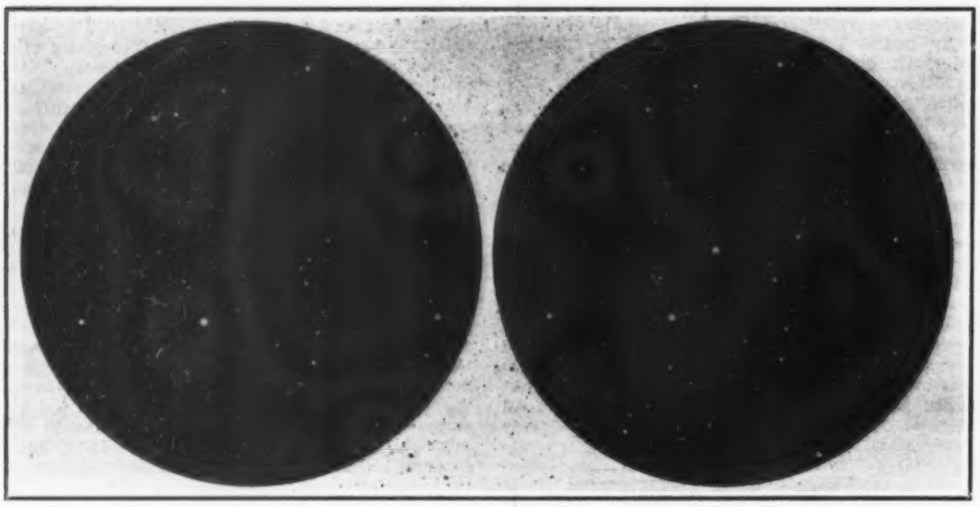


FIG. 1.—A VARIABLE STAR.

STEREOSCOPIC PICTURES OF THE HEAVENS.

By DR. MAX WOLF, Heidelberg University.

A VARIABLE STAR.

THE stereoscope is well adapted to the discovery of differences between two photographs, and Dove long ago suggested its employment for the detection of counterfeit banknotes. Every difference between the pictures produces a disturbing effect. If the same region of the sky is photographed at two epochs the comparison of the photographs in the stereoscope at once shows which stars have altered in brightness in the interval, for in the photographs the diameters of the star-disks vary according to the brightness of the stars. In this way a great many variable stars have already been discovered.

The stereograph here reproduced (Fig. 1) shows the variable star B Coronæ, which occupies the center of each picture. In one picture it appears bright, in the other dim, and this difference is immediately recognized as a disturbance of the general effect. The right-hand photograph, taken May 28, 1903, shows the star of the seventh magnitude, or comparatively bright. It was taken with our 16-inch telescope with an exposure of three hours. The left-hand picture shows the star dim, of the twelfth magnitude. It was taken on May 7, 1905, with the same telescope, and an exposure of 2 hours and 8 minutes. The faintest stars visible in the pictures were of about the fourteenth magnitude. The scale of the pictures is 35 millimeters (1⅜ inch) to one degree of arc.

A PLANET AND SATELLITES.

The planet Saturn occupies the center of the picture (Fig. 2). In the stereoscope it appears to float in front of the starry firmament. Two satellites are visible, one very close to the disk of the planet at the left, the other more distant, at the right and behind. The photographs were taken with our 6-inch telescope on two successive evenings, June 9 and 10, 1899, with exposures of 1 hour 40 minutes, and 2 hours. In consequence of the motions of the earth and Saturn the apparent place of the planet among the stars was different on the two evenings. The combination of the pictures in the stereoscope gives the appearance which the planet and stars would present to a gigantic being whose eyes were more than 2,000,000 kilometers (1,243,000 miles) apart.

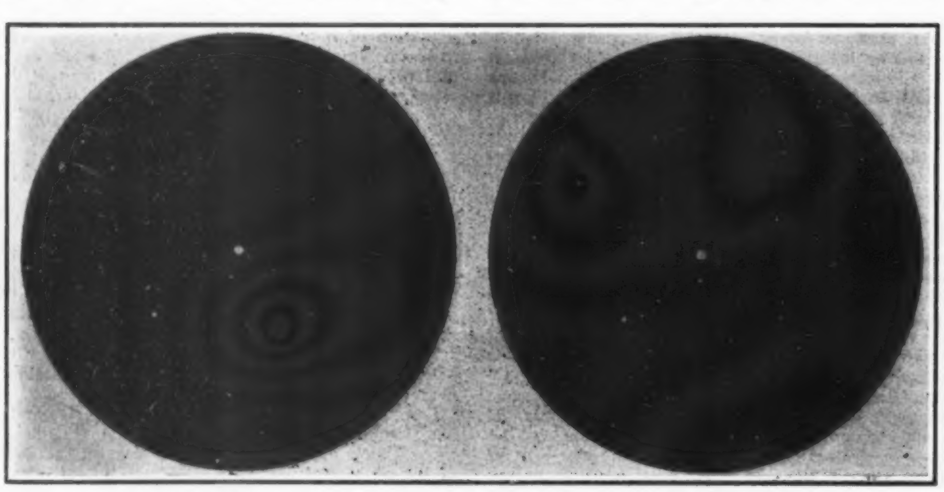


FIG. 2.—THE PLANET SATURN AND TWO OF ITS SATELLITES.

By measuring on the pictures the apparent displacement of Saturn with respect to the stars and taking account of the known real motion of the earth and apparent motion of Saturn, the distance of Saturn from the earth can be calculated. This displacement is measured, not directly, but indirectly, with the aid of the stereoscopic effect. A mark is affixed to one picture and a similar mark is moved to and fro on the other until the combined image of the marks seen in the stereoscope appears to be at the same distance as the planet. The lateral displacement of the mark which is required to produce this effect can then be read off from a scale or dividing engine. Zeiss's stereocomparator, which includes a stereoscope with an adjustable mark, is constructed upon this principle. By means of the stereoscopic adjustment the displacement can be determined with a probable error three or four times smaller than that of direct measurement of the lateral displacement of points of the picture.

From the pictures here reproduced, Dr. Pulfrich, of Jena, has computed the distance of Saturn as 1,260 million kilometers (783 million miles) which agrees very well with the value 1,270 million kilometers (789 million miles) demanded by the planetary theory.

Saturn's rings do not appear in these pictures. They are effaced by the light of the planet in consequence of the long exposure.

A SHOOTING STAR.

If photographs of a shooting star can be taken simultaneously from two widely separated points, the distance of the meteor from the earth's surface can be determined without difficulty by measuring the distance between the apparent positions among the fixed stars occupied by the trace of the meteor in the two photographs. In the stereoscope this displacement (the parallax) produces the impression of spacial depth so that the trace of the meteor appears to be drawn in front of the starry background.

The pictures (Fig. 3) here shown were made on August 12, 1904, with our two 6-inch telescopes, with an exposure of 5½ hours. The background represents the constellation of Andromeda, and 1 degree occupies about 14 millimeters (9/16 inch). It is possible that the stereoscopic effect is only apparent in this case, and due to an error in one of the photographs, but the pictures give a good illustration of this application of the stereoscope in cases where the effect is due entirely to parallax.

PROPER MOTION OF THE STARS.

The study of the relative motions of the stars is one of the chief objects of astronomical stereoscopy. In addition to their real motions the stars undergo apparent displacements caused by the motion of the solar system through space. As trees near a railway appear, when viewed from a moving train, to overtake and pass more distant trees, so are the nearer stars apparently displaced, relatively to the more remote stars, in our flight through space, which is now known to be directed to a point near the bright star Vega.

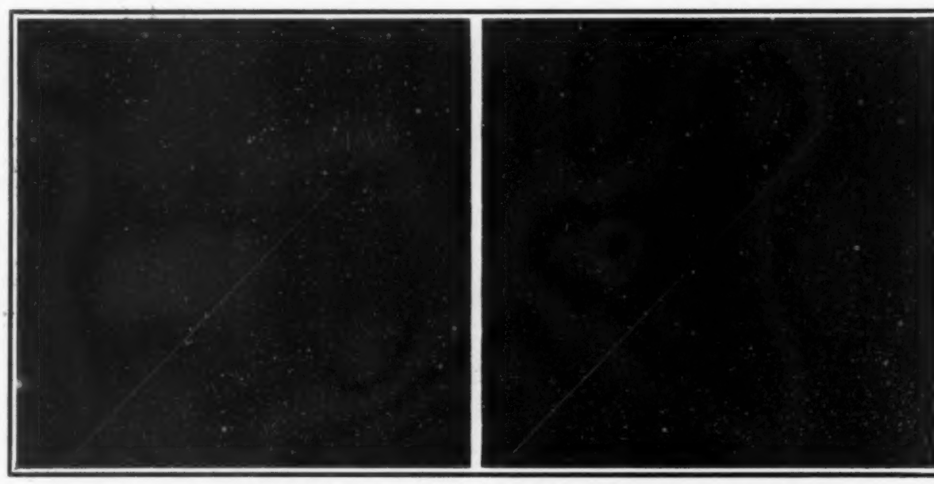


FIG. 3.—A SHOOTING STAR. ANDROMEDA IN THE BACKGROUND.

The pictures admirably illustrate the application of the stereoscope in cases where the effect is due entirely to parallax.

If two photographs of the same region of the sky taken several years apart are properly combined (Fig. 4) in the stereoscope, the more displaced stars must appear to be, as they are, nearer than the others. In this way we can learn in time which stars are greatly displaced and, knowing the motion of the earth, we can even compute the distances of all such stars from us. It is merely a question of time. Hence it is very important that photographs of the heavens shall be carefully preserved for future use. Their value increases with each succeeding year.

The central star in the accompanying pictures appears, in the stereoscope, far in advance of the rest. It is a star of the magnitude 8½ in the constellation of Orion, designated as Weisse I 5h, 592, which is known from meridian observations to have an annual apparent motion of 2¼ seconds of arc.*

The photographs were made with the Heidelberg 6-inch telescope, the left-hand one on February 5, 1896 the right-hand one on December 19, 1900. The pictures here given are enlarged so that 1 millimeter (1/25 inch) corresponds to about 30 seconds of arc. Besides the above mentioned star the stereograph shows several others brought forward less prominently. Thus we see how helpful photography, combined with the stereoscope, is in the study of these phenomena, and there is no doubt that by its aid problems which are now rarely attacked by astronomers because of their difficulty can be solved with comparative ease.

THE NEBULA IN ANDROMEDA.

Since the time of Herschel astronomers have eagerly sought to determine the solid forms and the motions of nebulæ, but as in all probability most of these wonderful objects are at immense distances from the earth there is little prospect of learning much about them from direct observation. Spectrum analysis

* R. A. 5 h. 26 m. Decl. —3° 42' (1900).

alone appears to promise any result. Therefore, there is little hope of establishing the spacial relations of these distant worlds by means of the stereoscope. But, because of our rapid motion through space, it must be possible, before long, to determine the relative positions of stars situated between us and the nebulæ, from which as a background the stars will be brought forward in the stereoscopic image, according to the principles already explained.

These photographs (Fig. 5) of the nebula in Andromeda, taken in 1901 and 1905, are to be regarded as an initial experiment of this kind. Although they produce little plastic effect in the nebula itself, yet the binocular view of the great whorl is far more impressive than the image presented by a single picture, and the observer, after long study of the details, imagines that he perceives and understands the whole structure of the nebula. There are also everywhere indications of the relative arrangement of the stars in space. This arrangement is not perceived when two simultaneous photographs of the nebula are combined in the stereoscope.

The left-hand photograph was taken August 18, 1901, with an exposure of 3 hours and 40 minutes, the right-hand photograph December 26, 1905, with an exposure of 4 hours and 21 minutes, both with our 16-inch telescope. One degree occupies a length of about 35 millimeters (1⅜ inch).

A LUNAR LANDSCAPE: THE APENNINES AND ALPS.

The original plates from which these stereoscopic pictures were enlarged were made in Paris by Loewy and Puiseux with the Coudé equatorial, on February 7, 1900, and April 20, 1896. The stereoscopic effect is due to the fact that the face which the moon turned toward the earth was not exactly the same on the two dates. The steep Apennine mountains at the top of the pictures are separated from the mountains in the lower (northern) part by a plain which is bounded on the left (west) by the Mare Serenitatis, and on the right by the Palus Putredinis. The conspicuous bright spot in the Mare Serenitatis is the crater Linnæus. Of the two craters with deep shadows in the center, the upper is named Autolycus, the lower Aristillus. To their right the crater Archimedes gleams forth from the darkness. The westerly (left) edge of Aristillus rises about 1,500 meters (4,921 feet) above the plain, and the diameter of the wall of the crater is about 54 kilometers (33.5 miles). The range northwest of the Mare Serenitatis is the Caucasus, and below it the Alps extend to the right. The valley that bisects them obliquely can even be recognized. The interesting circular wall with an inner crater between the Caucasus and the Alps is the well-known Cassini. One centimeter on the picture corresponds to about 80 kilometers on the moon (1 inch to 8,000,000 inches, or 126 miles). The stereoscope not only brings out clearly the relative heights of the mountains but causes the lower part of the general surface to recede from the observer in consequence of the spherical form of the moon.

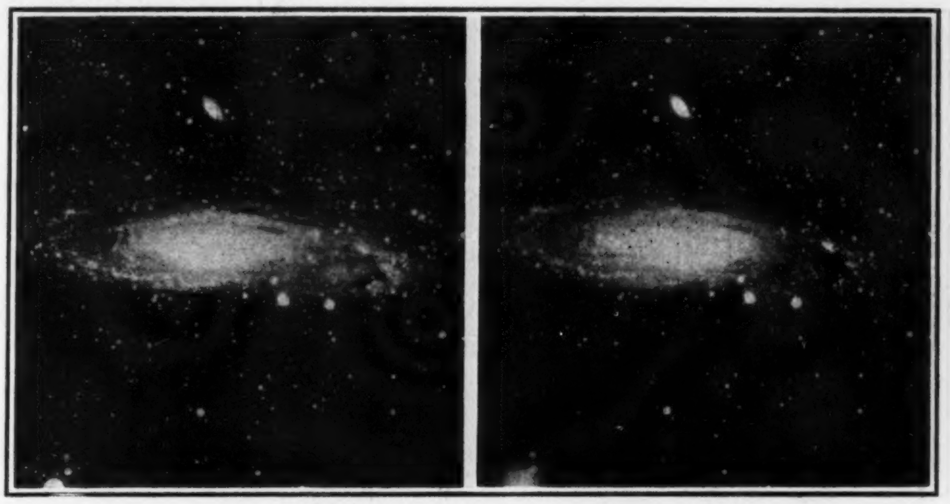


FIG. 5.—THE GREAT NEBULA IN ANDROMEDA.

The two pictures were taken at an interval of nearly four years apart.

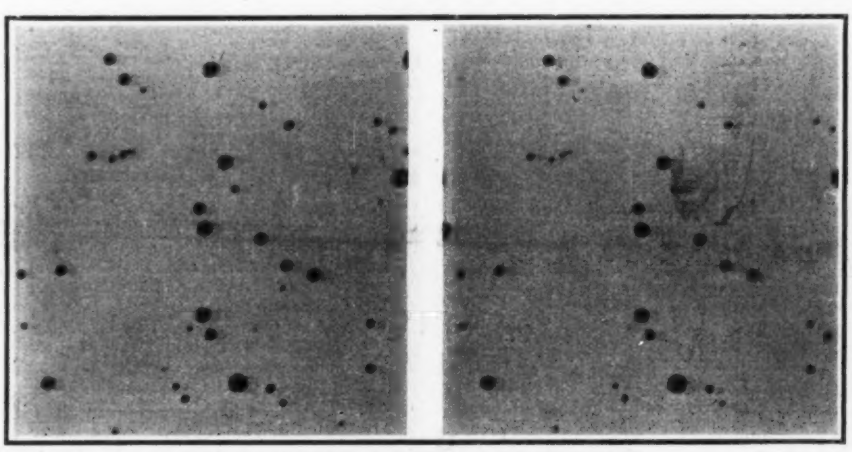


FIG. 4.—PROPER MOTION OF THE STARS.

RESOURCES OF MEXICO.*

By N. H. DARTON, U. S. Geological Survey.

THE rapid development of the resources of Mexico during the past few years has attracted widespread interest, especially in the United States. The production of her rich silver mines has steadily increased, gold has become an important product, and she has taken prominent rank in the copper industry. Her agricultural products have gained rapidly in value, manufacturing has increased to an encouraging extent and commerce with the outside world has multiplied many fold. Foreign capital has flowed into the republic, especially in later years, and many investors, confident of a continuance of the present stable conditions, are taking advantage of the many mining, railroading, manufacturing, and other openings which are available. The finances of the country are on a most satisfactory basis; many great public improvements have been made, and the government is offering encouraging facilities along all lines of development. Colonists are coming slowly, but as the conditions become better known they will undoubtedly take advantage of the large areas of public lands that are easily obtainable and in many regions can be utilized with great profit. The native labor is increasing in effectiveness, for many of the laboring people are showing considerable capability as workmen and artisans when properly trained. Lawlessness is no longer a menace to person or property, railroads are rapidly penetrating all parts of the country, and conditions of living are greatly improved. There is but a relatively small proportion of Mexico which is unhealthful to foreigners and many improvements have been made in this regard, notably in draining of the overflow area about the city of Mexico. With her great range of altitude, latitude, and rainful, Mexico presents various climatic conditions with a corresponding variety of agricultural possibilities. She has large areas suited for wheat, corn, and other products of the temperate zone, and in the hot, moist lowlands can raise many valuable tropical plants. Irrigation will redeem several hundred thousand acres in the north-central arid districts. Water power is available for many manufactures, considerable coal has been found in certain areas, and it is believed that petroleum may occur in sufficient amount to be an important auxiliary fuel.

Probably the most valuable resources in Mexico are the great mineral deposits, and mining will long continue to be her principal industry. For many years Mexico has produced more silver than any other country and now is gaining rapidly in output of gold, copper, and other metals. In 1906 the estimated value of her mineral production was 150,000,000 dollars (Mexican) of which about two-fifths was silver. During the past few years many of the old Mexican mines have been revived and some of the abandoned ones pumped out and modern methods installed. Large bodies of mineral have been discovered at many new localities, in some cases rich ores and in others ores of moderate richness which can be worked profitably by new processes. The extension of the railroad lines in various directions through the mineral country has been an important factor in development, for they afford outlet for ores which are not sufficiently rich to carry long distances by wagons or burros in the old-time manner. Smelters have been erected at many places and additional ones are in course of construction for the economical working of ores of various kinds. Modern methods of concentration are introduced at some mines which effect a saving so great that low-grade ores formerly thought to be of no value can often be worked with considerable profit. There are vast quantities of refuse and tailings from old mines and primitive reduction works which contain large values and some of these are being worked over with most satisfactory results. Often much fairly rich ore was discarded in the early days when only the high-grade material was worth freighting. On the old dumps at one mine in San Luis Potosi there are 300,000 tons of mine refuse containing much metal. In Guadalajara old tailings were used for the asphalt paving which recently was found to run $15 a ton in gold and silver. Electricity, generated mostly by water power, is now being utilized in some mining districts and proves to be most advantageous in many respects. It is estimated that about $80,000,000 of United States capital is invested for purchase and equipment of Mexican mines and large amounts have also been invested from other countries. The present high price of the various metals has given much impetus to Mexican mining, while the large amount of capital available in the present high tide of prosperity in the United States has been an important factor. The known mineral districts in Mexico are numerous and extensive and many portions are by no means fully developed. There are many regions also in which the mineral resources may prove important which have not as yet been explored by skilled prospectors.

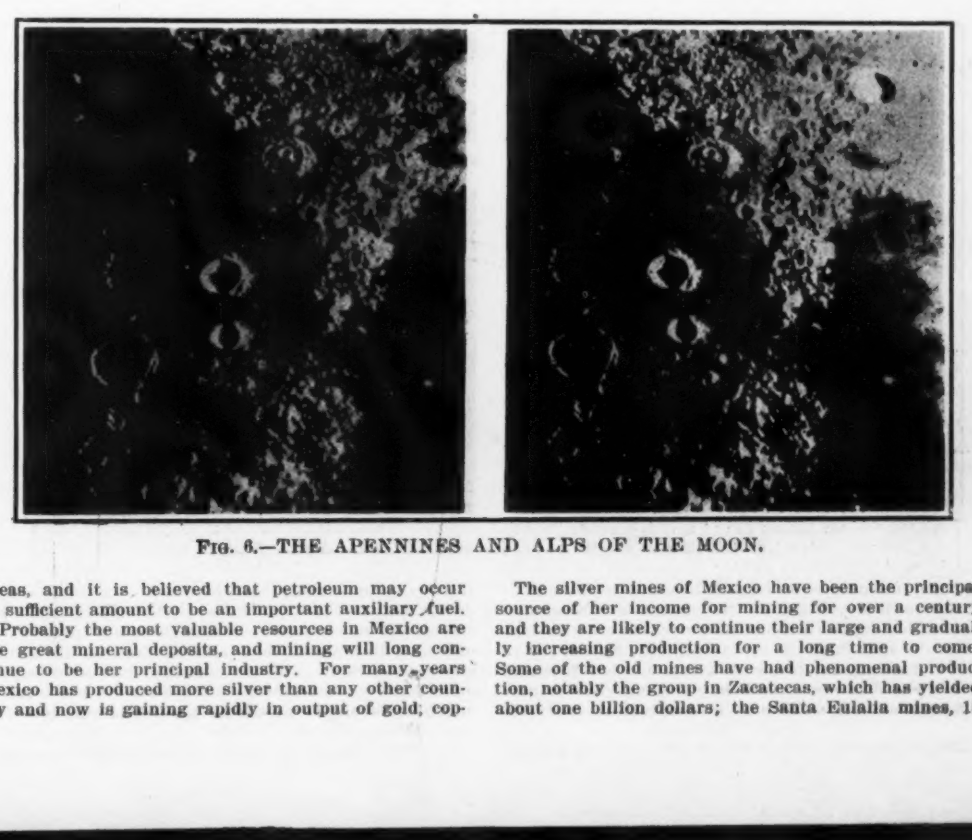


FIG. 6.—THE APENNINES AND ALPS OF THE MOON.

The silver mines of Mexico have been the principal source of her income for mining for over a century and they are likely to continue their large and gradually increasing production for a long time to come. Some of the old mines have had phenomenal production, notably the group in Zacatecas, which has yielded about one billion dollars; the Santa Eulalia mines, 15

* Abstract of an address to the National Geographic Society in Washington, D. C.

miles east of Chihuahua, two billions; while several score of others have many millions to their credit.

THE USE OF THE GYROSCOPE IN THE BALANCING AND STEERING OF AEROPLANES.*

By Robert H. Goddard.

An important point in aerial navigation that has not received much attention is the balancing of aeroplanes. The importance is obvious when one considers that the successful flier will undoubtedly embody the aeroplane principle; and that balancing must be automatic, if the apparatus is to be perfectly safe.

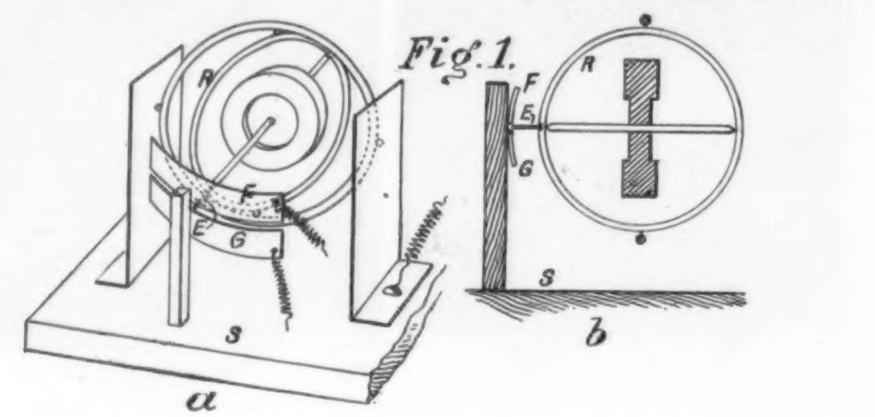


Fig. 1.

Balancing is, of course, automatic in the case of the bird; and the method employed by the bird may possibly be imitated. The organs by which equilibrium is maintained are known as the semi-circular canals. They are small, hair-like tubes, filled with fluid, in the bone of the skull, lying in three planes at right angles, each tube controlling, through delicate nerve-ends, the movements of the bird in its respective plane. Although it is not possible to reproduce artificially these complex structures, use can be made of a device which operates practically in the same way.

Everyone knows that a spinning top tends, with considerable force, to spin in one plane. This suggests a method of preventing an airship, with two equal wings as supporting planes, from turning in any direction, by using three gyroscopes at right angles to each other.

To illustrate how the governing action may take place, suppose Fig. 1*a* represents one of these gyroscopes. It is run continuously by electro-magnets (not shown) and is supported by gimbals so that it always maintains a horizontal position, no matter how the surface, *S*, is tilted. The surface, *S*, ordinarily is fixed to the airship so that it is inclined in the same direction and to the same extent as the airship. To this surface is secured an upright post, supporting two copper strips, *F* and *G*, of the form shown in the figure. Suppose, further, that we solder a fine wire, *E*, to the ring, *R*, which holds the gyroscope, and have the length of wire such that it can just graze *F* or *G*. Fig. 1*b*, showing a section of the gyroscope through its axis, will make this clearer. Normally, the state of affairs is that shown in Fig. 1*b*. The airship is not inclined; therefore *S* is horizontal, and the tip of the fine wire mentioned above lies in the narrow space between *F* and *G*, touching neither strip. If, however, the airship tilts to one side, *S* no longer remains horizontal, although the gyroscope remains so. Thus *F* and *G* have a motion either up or down, relative to the gyroscope axis, and hence relative to the fine wire. Under these conditions, this fine wire touches *F* or *G*, and we may suppose that, by so doing, it establishes electrical contact through magnets which tilt the forward edge of one wing in such a manner as to restore the airship to its original, horizontal, plane. All three gyroscopes

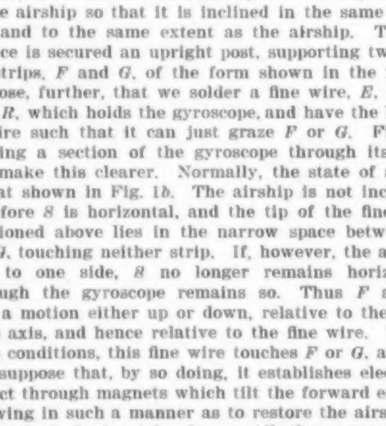


Fig. 2. Fig. 3.

are mounted upon *S*, which may be tilted by hand, if desired, in any direction.

It remains to show how this controlling apparatus may be applied. The device almost universally adopted for steering has hitherto been some sort of rudder; but from observations on the common chimney swift—a bird that seldom makes use of a tail—the writer has come to the conclusion that the successful flier, at high speeds, will require no rudder whatever. To indicate why this is probably so, let us suppose an unexpected current of air tends to overturn the swift. He simply moves the forward edge of one wing upward, and the forward edge of the other slightly downward. Fig. 2 shows the normal flight; Fig. 3, the turning movement. Thus he transforms his whole body into a sort of screw propeller. Remembering that his velocity is great, we can see that, by this action, he brings to bear an almost irresistible force tending to turn him back to his horizontal position.

Suppose, again, that the swift wishes to change the direction of his flight. He must first tilt his body at an angle, such that the wing on the side he wishes to turn, points downward; then the forward edge of this wing is tilted upward until the forward edges of both wings are tilted at the same angle. Reference to Fig. 4 will make this clearer. In this position the bird describes a curved path (in Fig. 4 the center of curvature of this path lies to the right of the figure) and travels in a straight path again only when the reverse of the whole operation is performed. Thus it may be seen how the swift has perfect control of the angle his body makes with the horizontal.

With the apparatus previously described, steering becomes a simple matter. Ordinarily the surface, *S*, moves with the airship, but in steering, it is inclined for a short time, by hand, in the required direction. As a result, the whole aeroplane is tilted. A curved path is then described, just as in the case of the swift's flight, until the aeroplane is turned back to its original position by a reverse operation. Thus it seems very probable that, for reasonable speeds, aeroplanes may be balanced automatically, and hence operated with comparative safety.

* Specially prepared for the Scientific American Supplement.

CANAL RAYS OR RAYS OF POSITIVE ELECTRICITY.

In the Philosophical Magazine, Prof. J. J. Thomson describes the results of a series of experiments on the streams in a vacuum tube, which have hitherto been known as Kanalstrahlen, but which he prefers to call "rays of positive electricity." These are the colored brushes of light which proceed backward (that is, in the direction opposite to that of the cathode stream) from a pierced cathode; the color depends on the gas with which the tube is filled and coincides with the color of the velvety glow which occurs immediately in front of the cathode. They were discovered by Goldstein. Wien showed that they could be deflected by a magnet, and that they were deflected in the opposite sense to that in which the negative stream would be deflected, thus proving that they consisted of streams of positively charged matter. Since they have been shown to be streams, the present writer would much prefer them to be called so; the term "ray" should be restricted to wave phenomena. For the same reason the term "cathode rays" arose when these were regarded as a kind of light; but when their true character was recognized, the term "cathode streams" replaced the original one to a large extent, though it has never completely supplanted it. (Varley, who was their first discoverer, called them "torrents.") The positive streams have been deflected by an electric force also. The value of the ratio of the charge to

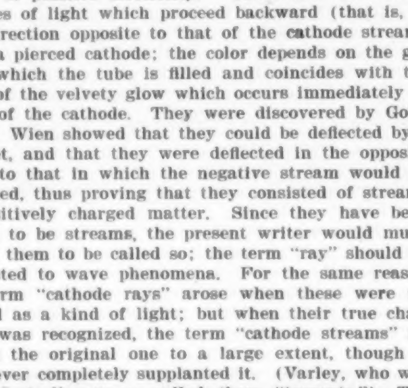


Fig. 4.

the mass has been ascertained to be the same as for an atom of hydrogen, as revealed in the electrolysis of solutions. Prof. Thomson has very considerably extended Wien's researches, realizing that a full examination of these streams would be certain to throw fresh light on the constitution of matter. By submitting them simultaneously to a magnetic and to an electric field, the patch of phosphorescence which they excite when they strike the surface of the tube (dusted over with powdered willemite) is drawn out into bands. When the band is straight it indicates that all the particles in the stream have the same velocity, but different values for the charge per unit mass. When there are two straight bands inclined to one another, there are two characteristic velocities. Now, for helium at moderate vacua, two such bands were obtained, for one of which the maximum value of the charge per unit mass comes out the same as for an atom of hydrogen, while for the second it is about one quarter of this. Since the helium atom has four times the atomic mass of an atom of hydrogen, the second band would seem to be due to charged atoms of helium. Now the alpha particles from radium are usually considered to be atoms of helium; but the value of the charge per unit mass for them is only half that of the hydrogen atom. There is, therefore, a discrepancy here. It is noteworthy that it is only in the case of helium that a second band characteristic of the gas employed was obtained.

With very high vacua, the bands are replaced by patches. These are two in number, whatever the gas with which the tube had been originally filled. One of these has the charge per unit mass of a hydrogen atom, and the other half this value; that is, the second corresponds to an alpha particle, or to a hydrogen molecule (i. e., a double atom). The special patch into which the second band of helium first of all changes as the pressure is lowered, disappears altogether at these very low pressures, and the helium now behaves like any other gas. With high vacua, in fact, there seem to be two kinds of carriers for positive electricity, and these carriers are the same, whatever the gas employed.

Although no clear explanation has yet been given of these results, it is obvious that they form a fresh starting point from which additional progress can be made in learning the true constitution of the atom. Negative particles (beta particles) of very small mass, are ejected from radium, thorium, etc., and forward from a cathode; positive particles of mass equal to a molecule of hydrogen are ejected from radium, and backward from a cathode; besides these the cathode projects backward charged carriers, whose mass is the mass of an atom of hydrogen. None of these differ with change in the substance from which they are obtained. They all, therefore, are common constituents of many kinds of atoms. More experiment is needed before any definite surmise can be made as to the real constitution of the atom. The idea that it is a congeries of electrons is completely given up. These and similar questions will be discussed at the Leicester meeting of the British Association in August next, in which discussion Prof. Rutherford and Sir Oliver Lodge have promised to take part. It is hoped that before then sufficient experimental advance will have been made to enable definite conclusions to be reached.

ELECTRICAL NOTES.

The application of heavy electric locomotives on the three-phase system for trunk lines of railroad was treated in a very able manner in a conference lately given by Engineer Hruschka at Vienna not long since, with especial mention of the Italian Valtelline system and the Simplon line. The Valtelline railroad has a length of 65 miles, and was started in 1902, while the Simplon section, started in June, 1906, is 13.5 miles in length. The experimental section is from Seebach to Wittingen, on which is running a type of Oerlikon locomotive. According to the *résumé* of the subject made by the author, the advantages of the three-phase system of locomotive lie in its simple and substantial build. The armature carries a ring collector which is superior to the commutator, but the newest Simplon locomotives have the collector suppressed, and the armature is run with short-circuited winding, using transformers for starting the motor. Another point is that the three-phase motor can be built for as high a tension as is wanted, and it is now used on 10,000 or 12,000 volts. Besides, such motors can be better disposed on the locomotive truck so as to obtain a high power with relatively small weight, and again there is no gearing. The disadvantages of the three-phase locomotive are the absence of a good speed regulating method, and there is but one speed which is economical. Then a double trolley line is required, and the two wires have the full tension between them. It may be thought that the line cost is greater, but this is not the case, and it is no more than for the single-phase system.

Electric traction for canal boats is now being applied very successfully in some parts of France, especially in the northern districts, using a special form of motor tractor which runs upon a narrow track laid along the canal. In the mining regions the system is proving quite a favorite for coal hauling, and among the lines which are now in operation may be mentioned a twenty-seven mile stretch lying between the localities of Bethune and Courchelettes, upon the Deule-Aire canal. Upon this section of the canal the annual amount of coal carried in this way is estimated at three million tons. Another system which has been put in operation since the former is the one now in use between Courrieres and Douai, in one of the principal mining districts. This is a shorter line, as it has not more than seven miles length, but there is a great quantity of coal carried from the large mines of Courrieres to Douai. By the use of the electric hauling system the rates can be lowered to a great degree over what are charged per ton for the usual method of hauling by horse. As an instance of what can be gained in this way, we may cite the figures given by the Compagnie Electrique du Nord. For one mile distance and the usual canal boat load as a unit, the rate in this case is $0.32 per boat-mile. In the case of horse hauling the rate is $0.40 or $0.50, and in some cases it may reach $0.65. These figures show what may be gained by the use of the electric system.

SCIENCE NOTES.

An investigation of the plant remains in Scottish peat mosses by Mr. Francis J. Lewis shows that in the southern uplands the stratified plant remains show a gradual change from a woodland condition to that of heath and moss, and then back again to woodland. In some localities a bed of Arctic plants is interposed between the two woodland ages. A corresponding sequence of the beds in widely separated areas is considered as furnishing evidence of varying climatic differences during the decadence of the Glacial period. Arctic plants are everywhere absent from the base of the peat, which consists of a forest bed containing birch and hazel remains.

Although silver is so readily deposited upon glass from aqueous solution as a coherent metallic film that mirrors are extensively manufactured in this way, it has not hitherto been found possible thus to deposit the metal copper, which in so many other respects closely resembles silver. In some mirrors exhibited at the Royal Society by Dr. F. D. Chattaway, the copper has been deposited upon the glass by reducing cupric oxide by an aqueous solution of phenyl hydrazine in presence of potassium hydroxide, which accelerates the action to a remarkable extent. The mirrors are equal in brilliancy and uniformity of surface to silver mirrors, and on account of the color of the copper are much more beautiful.

Dr. E. de Kruyff has described (Bull. Dept. de l'Agric. Indes Néerl.) his attempt to discover some use, on a commercial scale, for the watery substance contained in young cocoanuts. This attempt the author states was not crowned by success; nevertheless, some important results were arrived at during the investigation. The liquid is at first watery and clear, and with a sweet taste. In proportion as the nut ripens the liquid becomes denser, the sweet taste diminishes, and it assumes a frothy appearance. During this process a considerable amount of carbonic acid gas is disengaged. The liquid of the young fruit only contains among active sugars, a very small quantity of saccharose, and during the period of ripening this is converted into a glucose and levulose. This inversion of the saccharose is effected by the diastase sucrase, which is secreted by the cells of the albumen and becomes dissolved in the liquid. In addition to sucrase, oxydase, and catalase are also present in the liquid, the two latter being alone present when the fruit is very young.

New Sculptures at Trinity College.—After twenty-five years of waiting, work has been begun on carving the stones over the twelve entrances of the main building that were left for that purpose when Trinity College, Hartford, Conn., was built. Only two of the doorways will be cut at present. Some time ago members of the Class of '81 voted to give the money necessary to carve the stones over the first section doorway. Designs were submitted to President Luther by Halbot Entrees, of Hartford, and a young man's face, surmounted by an Oxford hat, was selected. Before the work was begun, Fred. Haight, an alumnus of the Class of '87, was so struck with the plan that he succeeded in having his class make a similar gift for the decoration of the next section doorway. A monk's head has been submitted as a design. It is not known, according to Dr. Luther's statement, whether this will be carried out or whether some other design will be used in its place. The monk's head was copied from a pair of rare andirons which were made in Florence a number of years ago, the molds being destroyed as soon as the first casts were taken. The andirons are now in the possession of one of the college fraternity houses.

The International Congress of Frigoriferic Industries, which is to be held at Paris at the end of 1908, will bring out the great progress in the application of artificial freezing methods during the last few years. Such methods are now used in many of the arts and industries, such as preserving of alimentary products, preparation of various products, transportation, and also in the army. Owing to the extensive use of such methods, a number of problems have come up for solution, and in view of the interest which the subject affords, it was decided to hold the present congress. The honorary president is M. De Freycinet, Member of the Institute and former Minister, and the president, M. André Lebon, former Minister of Commerce. The Congress will be divided into six main sections, and these again into sub-sections. M. D'Arsonval is in charge of the first section, which will be devoted to low temperatures and their general physico-chemical effects, also to health and food questions. Second section, M. Leauté; comparison of cold by using the compression of liquefiable gases and of other methods; unification of frigorific data; value of different non-conductors of heat; cold storage of explosive material. Third section, M. Gautier; application of cold to alimentation. Fourth section, M. Tisserand; application in other industries, including mines and public works. Fifth section, M. Levasseur; frigorific methods in transportation of products. Sixth section, M. Cruppi; legislative questions relating to the subject. As will be seen, the programme of the congress is likely to bring out some interesting data, and will give a *résumé* of the state of the art at present.

Condition of the Alhambra Dangerous.—The Governor of Grenada has convened a meeting of experts and prominent citizens to consider immediate steps to preserve the Alhambra, some of the buildings of which, it is declared, are in imminent danger of collapsing. The buildings range in age from about 660 to 550 years. Some of them were damaged by fire in 1890. The condition of decay into which they have fallen has attracted a good deal of attention lately, and the Spanish government has been criticised for its indifference to their preservation. The poor condition of the building is not due so much to its age as to the bad usage it has received at Christian hands. After Ferdinand had taken Grenada, the Alhambra was greatly defaced. The Spaniards even whitewashed it. Charles V. pulled down the greater part of the "winter palace" to make room for a palace of his own, which still stands, roofless, very much as he left it. Other changes which were not improvements were made by Philip V. In 1812, when the French occupied it as a fortress, they endeavored to restore parts of the interior, but when they evacuated it they blew up several of its towers in order to destroy the strength of its fortifications. In 1821 a violent earthquake made further inroads upon it, and it was not until 1862 that civilization had so far advanced in Spain as to make possible a true appreciation of its inestimable value. In that year Queen Isabella began the work of restoration, for which the world is in her debt, even though much still remains to be done to preserve it from decay.

TRADE NOTES AND FORMULÆ

Grafting Wax.—I. Wax, 75 parts; purified rosin, 125 parts; turpentine, 36; rape oil, 12 parts; Venice turpentine, 25 parts; zinc white, 25 parts. Color yellow with turmeric.

II. Japan wax, 100 parts; yellow wax, 300 parts; rosin, 800 parts; turpentine, 400 parts; paraffine, 100 parts; tallow, 300 parts; pine rosin, 600 parts.

An Adhesive Which Will Adhere to Tinned Plate.—According to a communication made by him to the Apotheker Zeitung, Lemoine prepares a paste which will adhere to tinned plate by mixing 2 parts of tragacanth powder with 16 parts of boiling water with vigorous stirring and then allowing the mixture to settle. Another process consists in preparing a mass from 4 parts of cold water, 6 parts of rye flour, and 1 part of dextrine, and combining it with the tragacanth solution. The mass is then mixed with 24 parts of boiling water with constant stirring, and further with 1 part of glycerine and 1 part of salicylic acid, and the whole boiled for three to four hours, stirring all the time. This mixture is somewhat complicated; anyone wishing to use ordinary starch paste should add a little glycerine; a mixture will be obtained which will be adequate in many cases.

To Stop Leakage in Casks.—If the leakage is considerable, thorough overhauling and repairing of the cask is recommended as the best and most radical remedy. If, however, it is only slight, and it is necessary to stop it at once, the following methods may be employed:

I. Melt a stick of sulphur on an open fire and add a little wax. Pour the mixture while hot and fluid into the seams of the staves or apply it with a brush. When cold, the mass will be hard and watertight.

II. Take 5 parts of quick-lime, 6 of white cheese, and 1 of water. Pass the powdered lime through a sieve, knead it with the moistened caseine, and spread the mass on the leaking seams of the cask, which should previously be cleaned.

III. Mix powdered quick-lime with some fresh blood; this mixture can be prepared rapidly, and is hence often used.

IV. The following is a favorite recipe: Mix 60 parts of hog's fat (lard), 40 of salt, 33 of white wax, and 40 of sifted wood ashes, and spread the mixture on the seams of the cask while hot. The leakage will be stopped at once.

To Make Leather Waterproof.—Prepare a zinc soap by dissolving 112 parts by weight of soft soap in 250 to 300 parts of boiling water, gradually pouring in 55 to 66 parts of zinc-vitriol solution. The zinc soap will float on the surface and form when cold a stiff mass of white color, which must be redissolved in boiling water in order to completely free it from potassium sulphate. Dissolve the pure soap in its own weight of linseed oil at 106 to 119 deg. C., place the leather in the solution and leave it there till the liquid is cold; air and moisture are driven out of the leather by the heat of the impregnating fluid, and as soon as the liquid boils the former penetrates into the pores of the leather, whereby the leather is rendered waterproof without becoming hard and brittle. Scrape off any excess of the compound and allow the leather to dry in the air. Only 48 hours are required for the treatment, including 3 hours for the saturation of the leather. Green copper or dark brown iron soap may be used instead of white zinc soap; it is prepared in the same way, using copper vitriol or iron vitriol. The following is another process: The mixture to be applied consists of 10 parts by weight of India rubber dissolved in 85 parts of pure turpentine oil, 150 parts of beeswax in 450 parts of turpentine oil, 21 parts of Burgundy pitch, and 10 parts of frankincense being added to the solution. When cold add 10 parts of good copal varnish, put the mixture in a large vessel, gradually add 450 parts of lime water in small quantities and stir thoroughly for 6 to 8 hours. The stirring must be continued during use to prevent the lime water from settling. To impart a black color to the impregnation, add 20 parts of lampblack, previously ground into a powder in 90 parts of turpentine oil. These 90 parts of turpentine oil must be deducted from the above 450 parts in order that the mass may not be too thin. Apply the mixture to the leather with a paint brush and rub it into the surface; when the impregnating fluid dries, the leather will be not only waterproof, but also soft and flexible.

ENGINEERING NOTES.

The Italian naval authorities have decided to sell or break up a number of battleships and other vessels during the five years 1907-12. The list comprises twenty-one ships of various classes, including the "Duilio" (launched in 1877) and the "Andrea Doria" (launched in 1891), as well as numerous torpedo-boats. With the proceeds, which are estimated at $1,300,000, the government intends to make large purchases of coal for the Italian navy.

The armor-plate factory at Terni, according to Page's Weekly, has accepted a contract to provide the Italian navy with 6,000 tons of armor plate at the same price as that at which the Midvale Steel Company, of Philadelphia, recently took a contract from the Italian government. Thus the contract with the American company has had the effect of forcing the Italian works to lower their prices, and the result is a saving of $80,000 to the Italian government.

In August of last year a British Departmental Committee was appointed to make inquiries as to what diseases and injuries ought to be set down under the head of "industrial diseases" in respect of which compensation would be payable by an employer under the Workmen's Compensation Act, 1906, where it is shown that they were contracted by a workman in the course of his employment. In the schedule of the Act six diseases are specifically named—anthrax, lead poisoning, mercury poisoning, phosphorus poisoning, arsenic poisoning, and ankylostomiasis (miner's worm), and the Home Secretary is given power to extend the number. As a result of the inquiry the committee recommends that the following among other diseases should be added to the list: Poisoning by nitro- and amido-derivatives of benzene (dinitro-benzol, anilin, and others). Poisoning by carbon bisulphide. Poisoning by nitrous fumes. Poisoning by nickel carbonyl. Poisoning by Gonioma Kamassi (African boxwood). Chrome ulceration. Eczematous ulceration of the skin, produced by dust or caustic or corrosive liquids, or ulceration of the mucous membrane of the nose or mouth, produced by dust. Epitheliomatous cancer or ulceration of the skin or of the corneal surface of the eye, due to pitch, tar, or tarry compounds. Compressed air illness.

Weed destruction on many of the Western railways is an important problem, says the Engineering Record. The lines which have light traffic are ballasted with dirt and the weeds grow rapidly to such a height that the movement of trains is materially retarded and the cost of operation consequently increased. Different plans for getting rid of this vegetation have been tried, but until recently the customary method was to keep gangs of men at work during the whole season cutting it down. Sprinkling the roadbed with salt and oil has not been considered successful on most of the roads which have tried it, and several attempts to burn the weeds have not been continued, indicating that for some reason this method was unsatisfactory. The Union Pacific Railway, however, has a burning car which has made a good record. It is a four-wheel car fitted with a gasoline engine which can drive the car at a speed of three to four miles per hour while burning weeds, or 12 to 15 miles while going to and from work. The engine also drives an air compressor which keeps a number of large tanks containing gasoline under pressure. At the back of the car there are three large inverted pans, somewhat similar to those used in many cities for heating asphalt before it is removed from paved surfaces. These three pans have gasoline jets below them so arranged that a mass of flame can be directed upon the road-bed for a width of 12 feet. The car will burn the weeds over a strip of 20 to 25 miles length in a working day, and is run under orders like a regular train. The best results have been obtained by burning down the growth when it has reached a height of 6 to 8 inches and then going over it again a few days later. This kills over the roots and leaves the road-bed free from vegetation, which is not the case when the weeds are cut down by a gang of men, for the roots are then left ready for development at once. The machine is said to go over the track at a cost of about $5.75 a mile, which is about one-quarter of the cost for a section gang.

TABLE OF CONTENTS.

The Scientific American Supplement. Index for Vol. 63.

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The * Indicates that the Article is Illustrated with Engravings.